

MY JOURNEY IN SCIENCE

Autobiography of an Indian Scientist

Select List of Books of Author

Functional Nanomaterials and their Applications.
Nanomaterials: Basic Concepts and Applications
Solid State Nuclear Track Detectors and their Applications
Ferroics and Multiferroics.
Scientific Vision in Sri Guru Granth Sahib & Interfaith Dialogue.
Professor Puran Singh: Scientist, Poet & Philosopher
Harmony in Science and Sikh Religion.
Vigyan de Krishme (Wonders of Science)
Sikh Dharam ate Vigyan (Sikh Religion & Science)
Amrika- Canada di Yatra (My Travels in America & Canada)
Meri Vishav Yatra (My Travels around the Globe)
Europe da Safarnama (Travelogue of Europe)
Mera Jeevan Safar (Journey of My Life)
Gurbani Di Saral Viakhia (Simple Exegesis of Gurbani)

MY JOURNEY IN SCIENCE

Autobiography of an Indian Scientist

Prof. H. S. Virk



© Author

My Journey in Science
Autobiography of an Indian Scientist

by
Prof. Hardev Singh Virk
Email : hardevsingh.virk@gmail.com
Mobile: 91 9417553347

ISBN : 978-93-85670
First Edition: Sept. 2018
Price : 300₹ 15 US\$

Published by
Gracious Books
23 Shalimar Plaza Opp. Punjabi University, Patiala.
0175-5007643, 5017642
graciousbooks@gmail.com
www.graciousbooks.in

Type Setting
Mannat Graphics
Chandigarh
Email: <raijaswantsingh@yahoo.com>
Mobile 09915861422
Printed: D K Fine Art Press, New Delhi

Dedication

I dedicate the English version of my autobiography to my grand children who inspired me to rewrite "My Journey in Science" in the language which they understand. It is dedicated to all the mothers who are image of God on this earth and to all the teachers who inspire their students to study science. It is dedicated to the seekers of Truth both in Science and Spirituality.

Acknowledgements

I offer my sincere thanks to all those scientists who helped me in my scientific journey in various ways by offering reprints, technical help, hospitality, samples for study and review of my papers. The list is inexhaustible but I will like to mention some prominent names, for example, RL Fleischer and PB Price (USA), the two pioneers of SSNTD technique; Robert McCorkell of Carleton University, Ottawa (Canada); Reimer Spohr and Christina Trautmann of GSI, Darmstadt (Germany) and R. Brandt of Marburg (Germany); G. Somogyi and Ilona Hunyadi from Debrecen (Hungary) and George Marx and Ester Toth of Budapest (Hungary); L. Tommassino and Fedora Quattrocchi from Rome (Italy) and Giovanni Martinelli from Modena (Italy).

I offer my sincere thanks to Prof. Abdus Salam, Nobel Laureate, for providing the grant under TWAS to set up Centre for Promotion of Science in Guru Nanak Dev University, Amritsar. I owe my gratitude to funding agencies like CSIR, DST, UGC, BRNS (DAE) and MEF, Govt. of India for liberal project grants. I am indebted to my research workers and collaborators, who made my journey in Science a fruitful experience and an adventure.

I offer my thanks to authorities of HPKV, Palampur (HP) for permission to set up Radon monitoring station on its campus. I am thankful to the Vice Chancellor, Punjabi University, Patiala for offering me the post of Professor of Eminence to work on a project "History of Science".

□

Contents

| | |
|--|-----|
| Foreword | 8 |
| Introduction | 14 |
| Part A: Making of an Indian Scientist | |
| 1. Memories of My Childhood and Family | 21 |
| 2. My Student Life: Up Against Odds | 35 |
| 3. Memories of Punjabi University Patiala and Paris | 49 |
| 4. Memories of Guru Nanak Dev University, Amritsar | 66 |
| 5. My Travels around the Globe: A Synoptic View | 79 |
| 6. Role of Women in My Life | 90 |
| 7. Memorable Events of My Life | 104 |
| 8. Literary Journey of My Life | 115 |
| Part B: Scientific Journey of My Life | |
| 9. From Cosmic Rays to Elementary Particles | 125 |
| 10. My Journey in Earth Sciences and Creation of Physics Department | 133 |
| 11. Radon Studies for Uranium Exploration and Earthquake Prediction | 142 |
| 12. Heavy Ion Radiation Damage Track Studies in SSNTDs | 150 |
| 13. My Encounter with Nanotechnology | 159 |
| 14. My Forays in History of Science & Other Areas | 164 |
| Appendix I: List of My Research Publications | 170 |
| Appendix II: List of My Published Books | 205 |
| Appendix III: A Preliminary Report | 208 |

Foreword

Dr. Hardev Singh Virk has a versatile personality. He is a devout Sikh, a world renowned Physicist, a research scholar, a great speaker of the international repute, a romantic Punjabi poet, a professor, a world traveler with a cosmopolitan outlook on life, and a rare blend of a scientific and artistic mind.

Behind the veil of a literary piece of autobiographical account, there is always a life, fully pulsating, heavily breathing, reflecting on its successes and failures and trying to forcefully express its true nature, which Dr. Virk succinctly dubbed as *the naked truth*. *My Journey in Science: Autobiography of an Indian Scientist* is a riveting and an attractive showcase of the struggles, successes, glories and failures, frustrations, reflections of a visionary, hardworking, an experienced, devoted and a dedicated scientist.

A Renowned Scientist among the World Scientists: Dr. Virk has the honour and privilege to have Dr. Piara Singh Gill as his professor and mentor who was a world famous Indian physicist, a pioneer in Cosmic Rays physics. It is truly a matter of great honour and pride for a person to arise from poverty and less fortunate circumstances to join the gallery of the greatest scientists in the world as colleagues, mentors and teachers.

Dr. Hardev Singh Virk is currently a brightly shining star, a Sirius, in the galaxy of the world scientists. I believe through hard work, brilliance, and intelligence, distinct and unique accomplishments, Dr. Virk arose to join the company of elite scientists and scholars of national and international prominence. Some of his personal acquaintances include, Nobel Laureate, Prof. Abdus Salam from Pakistan, and a galaxy

of world renowned scientists mentioned under Acknowledgements. Hardev also had the great opportunity to meet and listen to Nobel Laureates, Murray Gell-Mann, Samuel C.C. Ting and Leon M. Lederman from the USA, and Peter Higgs from UK, who delivered lectures on Particle Physics.

Dr. Virk's Shining Accomplishments: I have taken the liberty to list Dr. Virk's highly prestigious honours and accomplishments briefly as follows: (a) "Most Honorable" in Doctoral Dissertation of Marie Curie University, Paris (1972); (b) Award as the Best Writer of Scientific Literature in Punjabi, Govt. of Punjab (1993); (c) First Prizes for Scientific Text Books in Punjabi medium, awarded by Punjabi University, Patiala thrice; and (d) Templeton Foundation (USA) Honorable Mention Award for Research Project: Global Perspectives of Science & Sikh Religion (2005). An exhaustive list of his publications is given in Appendices I & II, listing his research papers in Physical Sciences (highest number in Punjab) and the list of Books in areas of science, technology, religion and literature.

Dr. Virk's Identity as a Sikh: Dr. Virk is a Sikh not only because he was born and raised in a Sikh family. He has provided a very interesting and intriguing explanation about his deep interest in Sikhism: *"People ask me why I love Sikhi? I tell them it is in my genetic code. My mother did so much recitation of Gurbani (utterances of the Gurus) when I was in her womb, that it changed my genetic code. If transmutations are possible in radioactive substances in nature and can be induced artificially in a research laboratory where I worked in the Marie Curie University of Paris, then why not at the biological level in a foetus?"*

Dr. Virk's ingenuity in applying scientific explanations to religious or spiritual questions is at *par excellence*. The above cited example from Chapter 6 is quite fascinating and thought-provoking, a scientific question for many others to explore. It

would be very difficult, if not impossible, to dispute Dr. Virk's assertions and logical explanations.

Some Loving and Beautiful Women in Hardev's Life:

Hardev has adored and appreciated women in a form of many diverse roles and attributed them highest place in the hierarchy of love and respect. He worshipped his Mother as the first best God when he asserted: *"In my life, I saw the woman not as the second best God but as the first best God in the image of My Mother. She not only gave me birth but also kept me tuned to the celestial realms of Sikh spirituality"*. There is no better tribute which could be offered to one's Mom. For Hardev, his mother was a great source of love, affection, and security.

Another lady, Hardev's *Bhua* (Father's sister) also became a role model for him. In the face of all adversities and travesties of her life, she managed to receive education and became a teacher to lead a life of self-respect and self-pride. Dr. Virk had a deep respect and appreciation for his *Bhua* whom he described as a lady of an iron-will. The sad story of his *Bhua* stands as a shocking reminder about the Punjab's many women who are deserted or rejected after the marriage without divorce and legal resolutions. In every village, there are some women who had to live at their parental home for the rest of their lives.

Romantic Entanglements: I immensely commend and appreciate Dr. Virk for sharing his private and personal world through candid and daring self-disclosure when others will shy away discussing their romantic entanglements, sexual insinuations, love longings and hopeless infatuations as described in chapters 6 and 7. Dr. Virk is a man of high moral and spiritual principles, couched in the philosophy of Sikhism. For this reason, romantic attractions and snares of Felicia, Labiba, and Marie Claude could not entrap him. Dr. Virk sought the protection of Guru Gobind Singh from succumbing to the

charm of the ladies mentioned in his autobiography, as Bhai Joga Singh was protected by the Guru. However, some readers might question Hardev's intentions and interests for continuing and long lasting relationships with these women especially with Marie Claude. Only plausible answer to the queries of these readers would be that *Hardev* values friendships and Platonic love which don't necessarily involve sexual fantasies and interests..

Adversities and Travesties in Dr. Virk's Life: Dr. Virk's autobiography is replete with challenges, frustrations, and agonies in life. In his personal life, benign neglect from his father, apathetic attitude of his step mother and open hostility from his step brothers caused untold amount of anxiety, worries, and obstacles in his life. Hostile attitudes from both collateral and lineal descendents (*shariq*) in a Jatt family of Punjab are portrayed with the stunning accuracy in Hardev's autobiographical account.

Similarly, the professional hurdles for Dr. Virk to secure the most deserving position as the Vice-Chancellor of a University in Punjab, are very candidly portrayed in his autobiography. The very sad spectacle of bribery, corruption, nepotism, and *sifarsh* (inappropriate approaches or recommendations) are quite prevalent in India in general, and in Punjab, in particular. Sad but true to a large extent, the most deserving and meritorious candidates like Dr. Virk are passed over by those who have political connections or plenty of money to bribe. Unfortunately, meritocracy is sacrificed at the altar of many crooked practices of hypocrisy, avarices, and abuses of political powers.

I admire Dr. Virk's courage to share his personal and professional life very openly without any reservations. Behind autobiographical work of Dr. Virk, we see a person of profound scholarship who has produced pioneering research well

recognized throughout the world. Specifically, Modgil-Virk model and his Radon studies for Earthquake prediction research have a potential to make Dr. Virk stand in line with eminent scientists of the world.

To finalize, I metaphorically compare Dr. Virk with the *Lotus flower*, born and raised in the mud and mire of poverty and life of afflictions. Dr. Virk blossomed as a beautiful Lotus flower and smelled like a rose whose romantic and sweet fragrance of fame and scholarship travelled all around the world from the Royal City of *Patiala*, Punjab to the romance capital of the world, *Paris*, France.

I commend and congratulate Dr. Virk for treasuring his life experiences of joys and sorrows in the golden box of eternal memory of a published autobiography. I also thank him for inviting me to write this *Foreword* and allowing me to become a permanent part of his long-lasting memoir.

Dr Virk's Writing Style: Dr. Virk's autobiography is quite captivating and engaging. Once you start, it is very hard to put it down without reading it from the start to the end. He has a great mastery of presenting his life experiences in a vivid and picturesque style. The whole autobiography is replete with open and honest reflections. Eloquence and elegance are two salient hallmarks of Dr. Virk's writing style.

Despite numerous challenges and obstacles in his life, Hardev presented a great zest for life in his autobiography. He also created a constant intellectual curiosity and gripping desire and interest for the readers. The whole book is easy to read and comprehend. Most interestingly, I am truly amazed how Dr. Virk has shared all the information so meticulously and with minute details of dates, times, and places.

To Sum Up: Writing an autobiography gives an impetus to a journey of self-discovery, inspires introspection, and creates the process of self-reflection. It captures and portrays one great

picture of hopes, dreams, successes and sweet memories. Only through writing one's life story, a person becomes fully aware, fully conscious and can gain the context and recognize the true meaning of one's life, Dr. Virk's must be applauded for this monumental work. Only a few persons of his intellectual calibre, education, and extensive experiences of life are able to tell their own story in their own words.

More importantly, it can provide catharsis and healing to the psychological wounds from the past. An autobiography could also provide resolution and offer peace to the troubling psychological crises which refuse to give away. Only Dr. Virk could answer if after writing his autobiography, whether or not he received the lasting resolutions to his persistently painful memories from the past. But I am pretty sure that he has been very successful in creating a showcase of his outstanding successes of his personal and professional life.

Dr. Daya Singh Sandhu
Director of Research, Lindsey Wilson College
Columbia, KY 42728 (USA)
Chairman and Distinguished Professor of Research
(Emeritus) (1991-2015)
Educational and Counseling Psychology
Louisville, KY 40292 (USA)
Senior Fulbright Research Scholar
Punjab University, Chandigarh(2002);
GNDU Amritsar (2010); PU Patiala (2017-2018)

Introduction

I was motivated to write my autobiography “*Mera Jeevan Safar*” in Punjabi after reading “Up Against Odds”, the autobiography of Piara Singh (PS) Gill, who was my mentor in Physics at Aligarh Muslim University (AMU), Aligarh. PS Gill passed high school from Mahilpur, immigrated to Panama in Latin America to work as a taxi driver and then studied in California, USA, doing odd jobs to support his education. Ultimately, he rose to be a renowned Cosmic Ray physicist after working for his Ph.D. under the supervision of Nobel Laureate, A.H. Compton in Chicago University. Gill was my teacher in AMU Aligarh and role model for rural students of India who have to struggle hard to get higher education in Science.

My own journey in science has been a life of struggle. My education starts in 1948 after the partition of India in a one teacher rural primary school. Reaching Marie Curie University, Paris for higher studies leading to Ph.D. in Nuclear Physics was my dream project. Gill inspired many young students from Punjab to join AMU for M.Sc. and Ph.D. in Physics. I was one of them in 1961-63 batch, just before he left Aligarh to join as Director, CSIO, Chandigarh.

I have read very few good books in the genre of autobiography. “The Tale of Four Cities” is an autobiography of Jayant Narlikar, a renowned astrophysicist of India. In comparison to PS Gill, Jayant was a privileged student of science, who was a scholarship holder in Cambridge University and whose father, Vishnu Narlikar, himself was a ‘Wrangler’ in Cambridge. Homi J. Bhabha, who was a scion of the famous

Tata family, had been a privileged scholar in Cambridge. He made pioneer contributions in the field of Cosmic Rays and became the architect of India's atomic energy programme. Others who influenced my life in Science were Abdus Salam, the Nobel Laureate from Pakistan, and Prof. Puran Singh, the scientist, poet and philosopher; a rare genius of Punjab.

The title of my autobiography "My Journey in Science" with a sub-title: "Autobiography of an Indian Scientist" is chosen with a purpose to showcase all aspects of my life as an Indian scientist. It has been divided into two parts for sake of convenience of readers. In part I, "Making of an Indian Scientist", there are eight Chapters and Part II "Scientific Journey of My Life" contains six Chapters. Essays in Part I focus on my personal life. Essays in Part II describe the diverse areas of my research, trials and tribulations of inter-disciplinary research, followed by our research publications in research journals given as appendix I. The last Chapter of the book includes my journey beyond the frontiers of Science into other domains, for example, History & Philosophy of Science, Physics Education, Sikh Religion, and Punjabi Literature.

First Chapter "Memories of My Childhood and Family" is based on the story of my birth as a blessing of a holy man (saint), the partition of India, my early school education, problems of my adjustment in paternal family, and vicissitudes of my mother's and my own life. The heart-rending tales of partition, glimpses of my maternal and paternal families, and meeting my better-half in Chandigarh as a mere coincidence without any prior planning and dating, are all parts of this chapter.

Second Chapter "My Student Life: Up Against Odds" is based on the most difficult phase of my life. I may call it 'riddles of my student life' as there was no light at the end of the tunnel. It is a story of murder of my *Nani* (maternal

grandmother) for sake of landed property, as a consequence reducing my family from riches to rags, my determination to join a college without any hard cash with the family, and the help of my school and college teachers who proved to be benefactors in my life. It is a decade-long story of my adversities which made me strong to face any difficult situation in later life.

Chapter three “Memories of Punjabi University, Patiala and Paris” may be called the golden era of my life. I moved from a college to the university, got married and sired three sons, went for my doctorate in Nuclear Physics to Marie Curie University Paris, took my first steps in scientific research, and published B.Sc. level textbooks to teach science in Punjabi medium. A peep into my participation in teachers' politics, parliamentary elections, and my exploration of Sikh cosmology in the Sikh scripture are described in this chapter.

Chapter four “Memories of Guru Nanak Dev University (GNDU), Amritsar” covers the longest span of my life spent in the service of GNDU from 1979 to 2002. It is a tale of starting a new department of Physics at GNDU, creating infrastructure for research despite many handicaps, setting up research collaborations in inter-disciplinary fields of research, participation in national and international meetings and conferences, and to start earthquake prediction studies using Radon/Helium as precursors. A passing reference to Operation Blue Star in Punjab and its impact on GNDU, my contributions in Punjabi literature, popularisation of science under an ICTP project, visits to ICTP, Trieste (Italy) and meetings with its Director, Abdus Salam, are included in this chapter.

Chapter 5 “My Travels Around the Globe: A Synoptic View” presents a sample survey of my voyages around the globe. Most of these are included in the three volumes of travelogues already published in Punjabi in 2008. A sampling

of these travelogues to Hungary, China and my circuit of Singapore, Malaysia, and Thailand is given in this chapter. I am planning to prepare a compendium of these travels to promote inter-cultural understanding at the global level.

Chapter 6 “Role of Women in My Life” is a tribute to my mother, wife and other young ladies who came into my contact during my days of solitude in Paris. Like any other young boy in his teens, I was also infatuated by the presence of beautiful girls in my school and college days. Under the heading “My Love Affairs in Paris”, I have faithfully described my encounter with three beauties without mincing any words. I will like to call it a naked truth of my life. I was impressed by reading an autobiography of Prof. Pritam Singh, a doyen of Punjabi literature, where he speaks about his love affairs without any inhibition. I have tried to follow in his footsteps. Out of Felicia, Labiba and Marie Claude, only the last one remains in my contact ever since 1971.

Chapter 7 “Some Memorable Events of My Life” is based on the real happenings of my life. Those readers who are non-believers in spiritual reality or are prone to logical and rational thinking may consider some of my real life events as cock and bull stories. I have given only six events, there were many more, some of which appear in other chapters of this book. ‘Power of Prayer’ and ‘My Gandhian Experiment’ are as true as the daylight. ‘An Unfulfilled Wish of My Life’ is a poor reflection on the Indian education system and its follies.

Chapter 8 “Literary Journey of My Life” is a window on the literary phase of my life. In college days, I started writing Punjabi poetry and this phase ended as soon as I got a teaching job in an engineering college. I owe this trait of my college life to the influence of some of my friends who used to write poems. To name a few, I may mention Ujagar Singh Kanwal, Kulwant Grewal, and Navtej Bharti. It is almost impossible to

translate Punjabi poetry into English due to different cultural ethos and nuances. I lost my interest in poetry reading and writing under the influence of my scientific investigations. There was a temporary revival of this trait during the phase of 'My Love affairs in Paris'. Due to the difficulty of translation, I have selected only a few poems and folk songs for rendering into English.

Part II of this volume consists of six chapters. Readers with a scientific bent of my mind will relish the stories of "Scientific Journey of My Life" more than others. The contents of these Chapters reveal the different phases of my life from a Masters student in Physics at AMU Aligarh to doctoral student in the Marie Curie University of Paris. Chapter 9 "Moving from Cosmic Rays to Elementary Particles", tells the story of my joining AMU Aligarh, search for a research supervisor in Paris, harassments faced before the thesis submission at the hands of my research supervisor, return to India and frustrations of continuing research in India.

Chapter 10 "My Journey in Earth Sciences and Creation of Physics Department" is an interesting story of my changing the research field from Particle Physics to Earth Sciences and creation of Physics department at GNDU Amritsar. The problems of university administration, creating infrastructure for teaching and research, and presenting results of research in International forums are part of this chapter.

Chapter 11 "Radon Studies for Uranium Exploration and Earthquake Prediction" revolves around my research in GNDU using Radon studies as a tool for biogeochemical exploration of Uranium and exploitation of Radon as a precursor in the prediction of earthquakes in Punjab and Himachal Pradesh. Our group created the largest database on Radon measurements in soil, air, and water in India using multi-parametric approach.

Chapter 12 "Heavy Ion Radiation Damage Track Studies

in SSNTDs” describes our research investigations in Solid State Nuclear Track Detectors (SSNTDs), an area with immense applications in diverse fields. We were pioneers in using ‘Heavy Ion’ beams for irradiation of SSNTDs in India. Our investigations led to the formulation of a ‘Single Activation Energy’ model of radiation damage annealing in SSNTDs.

Chapter 13 “My Encounter with Nanotechnology” is the story of my post-retirement research in DAV Institute of Engineering and Technology (DAVIET), Jalandhar. The highlight of our research in nanotechnology is the fabrication of nanowires and nanoflowers of exquisite beauty which appear to be analogues of real flowers in a botanic garden.

Chapter 14 “My Forays in History of Science & Other Areas of Interest” shows a panorama of my life and presents the wide range of my research interests in areas as diverse as history and philosophy of science, Physics education, Sikh religion and Punjabi literature. I have been fascinated by the philosophy of science and its approach to the question of ‘Nature of Reality’ ever since my university days in Paris. After retirement, I have been involved in the problems of ecology of Punjab state. My investigations are pointing to the health hazard risks to which population of Punjab is exposed. The appendix III to this chapter “A crisis situation due to Uranium and Heavy Metal contamination of ground waters in Punjab: A preliminary report” is a pointer to the crisis situation in Punjab.

The chapters 9-14 are followed by a comprehensive list of research publications based on our research investigations as Appendix I. These papers and documents are available on Research gate site: www.researchgate.net/profile/Hardev_Virk/publications. The list of my published books is added as Appendix II. I have used some original Punjabi terms with their English equivalents in brackets to describe events of my

early life and family relationships to make comprehension of the text easier for readers not familiar with Punjabi culture. As a scientist, I had to upgrade my knowledge in science and technology through collaborations with research centres in Europe and America. I acknowledge their help and my gratitude to all research collaborators and research scholars of my group.

Dr. Hardev Singh Virk
Professor of Eminence
Punjabi University, Patiala.
Ex-Director, Earthquake Research Centre
Guru Nanak Dev University, Amritsar.
Ex-Director, Nanotechnology Research Centre
DAVIET, Jalandhur(2008-2011).

□

Chapter 1

Memories of My Childhood and Family

I was born in a small village '*Majhinwala Bhuler*' (Chak No. 270) in District Lyallpur (now Faisalabad) now in Pakistan. The exact date of my birth was not recorded anywhere. My school teacher entered it as 23rd February 1942 by assuming that I must be six years old, the day I joined the primary school Lasso in 1948. My mother used to tell me that I was born after midnight on a full-moon night known as *Puranmashi* in common parlance in Punjab. According to the Hindu calendar, it was an auspicious day of *Rakhi* when sisters tie a sacred thread (*Rakhi*) on the wrist of their brothers, as a guarantee of protection of their honour for life. When the news of my birth spread in the tiny hamlet, young boys and girls of the neighbourhood came to tie *Rakhi* on my delicate wrist. In our rural community of pre-partition Punjab, birthday celebrations were not in vogue. So I never bothered to celebrate my birthday till I retired from Guru Nanak Dev University, Amritsar in June 2002. After retirement, I started visiting my family in Canada in 2002 and my grandchildren started my birthday celebration coinciding with *Rakhi* day, which moves from year to year as per Hindu (*Vikrami*) calendar.

I was born in my *Nani's* (maternal grandmother) house, as it was a common practice in those days that before delivery would be mothers would move to their parents home. The other possible reason was that my father had married a second wife before my conception and my mother found it convenient to deliver me at her parental home. She had lost her three

offsprings at a very young age and I was her last hope in life. Mother used to tell that my *Dadi* (paternal grandmother) forced my father to opt for a second wife fearing that all our landed property will be inherited by our coparceners if there is not a surviving male issue in the family. My mother was a devotional lady and she started reciting Gurbani (holy hymns from the Sikh scripture, Sri Guru Granth Sahib) most of her time, visiting Gurdwara (Sikh temple) both times regularly, and meeting the holy men (Saints) visiting our area. One saint, known as *kali kambliwale* (wearer of black robe) from Gobindgarh town visited my *Nanke pind* (maternal village) and blessed her that a son will be born to be named Hardev (Har and Dev are both names of God). He also commanded that mother and son should stay vegetarian for five years after my birth. My mother started eating meat after five years but it was such an abhorrence for me that I vowed to remain a vegetarian for the whole of my life.

We both stayed in *Nanke pind* till I was five years old. My mother was respected by all in her parental village and I enjoyed the immense affection of my maternal relatives, again a thing of the past now. The village doctor advised my mother not to keep lifting her son in her lap without any rhyme or reason and allow me to play in the dust among the rural youth. Mother took extra care to keep me in her safe custody. I was not allowed to enter village pond or a canal passing nearby our village for bathing in summer months fearing that I may not drown in water. I was told that my elder brother had died of drowning in a pond when he was hardly two. Hence, in spite of being born in a Virk clan known to be ferocious in the old times, I remained meek and mild-natured in my life.

My *Nani*, Jiwan Kaur, was a brave woman. She took lot of interest in agricultural activities and I used to accompany her to the farm on the outskirts of the village. *Nani* had no

male issue but gave birth to three daughters. The elder two were born with handicaps as both were born deaf and dumb. Despite these handicaps, both were married in farming families and raised their families very well. My mother was born as a normal child and was engaged in household activities as a young girl and got expertise in all the chores of a farming family. She was married to my father at the young age of 16 in a flourishing township of *Kamoke mandi* (a market town) in district Gujranwala (now in Pakistan). When father married the second time, she started living with her parents and did not ask for a divorce, as it was not a wont in rural Punjab of pre-partition days.

There was no facility for primary education in my village of birth. Most of the young boys of the village had to trudge a few kilometers to a nearby town of Jalandhar to study in the primary and high school. My father was a high school dropout but he was very keen that I should go for higher education. He came to my *Nanke pind* towards the end of 1946 and got me admitted to the primary school of Kamoke when I was almost six years old. I still remember vividly the location of my school on the famous grand trunk (GT) road of India. My school teacher was a Muslim and we started learning Urdu alphabet and three Rs in the first year primary class. Our classmates were mostly Muslim boys who used to tease me but there were no racial remarks or harassment of any kind based on religious distinctions. We had hardly finished a few lessons of our primer of Urdu and memorised some multiplication tables when the disturbances started in Punjab on the eve of partition. In fact, during March 1947, the riots took place in Rawalpindi district and Sikh and Hindu families of the area started moving to Indian Punjab even before the partition of India on 15th August 1947.

Memories of Partition of India: I am a witness to the trauma

of partition. The Mountbatten Plan that India will be partitioned into two countries, India and Pakistan, was declared in June 1947 and the Indian Independence Act received the royal assent on 18 July 1947. According to this Act, Pakistan came into existence on 14 August and India came into being on 15 August 1947. The Radcliffe or the boundary line was drawn hurriedly and the border was porous till the last moment. On 14th August morning, shooting started in our town. The police officers were mostly Muslim and they did not bother to control the rioters. By the mid-day, we started assembling in Jathedar Hari Singh's house as he had licensed rifle and other weapons of offence and defence in his house. While leaving in panic, my mother took nothing but a glass of steel for drinking water and caught hold of me in her hand tightly. She was reciting a hymn from Gurbani "*Tati vao na lagie....*" which roughly translates to "when you are under the protection of God, no hot wind will touch your body". Whenever I was sick or in trouble, I found mother chanting this hymn and I also adopted its practice in my life.

Most of the families in our *mohalla* (street) thought that partition is a passing phase and we shall return to our homes. My *Dadi* was polio-stricken from her childhood and could not walk without her support. She preferred to stay back. From Jathedar's house, we moved to GT road in a group where a military truck was waiting for all of us to be transported to Lahore. All of a sudden, my father was reminded that his mother (my *Dadi*) had been left behind. He took the risk of bringing her back to the waiting truck despite the fact that marauding gangsters were roaming in the streets. Before he could return, our military truck moved ahead to Lahore camp. My father with her mother had to stay back in the Gurdwara for two weeks before they were transported to Amritsar. Our refugee camp in Lahore was attacked once by Muslim rioters but we were saved being under the protection of Indian military.

After a few days, we crossed the Wagah border and reached Khalsa College Amritsar where a camp for refugees was set up. My father and *Dadi* joined us in Amritsar camp after two weeks and we heaved a sigh of relief. It was a traumatic experience for the whole family.

It was rainy season and the climate was hot and humid in the Amritsar refugee camp. The only respite was our visits to the Golden Temple for prayers and a dip in the holy tank (*Sarovar*). My mother took me to Medical college hospital on the way for a dressing of my wound under the knee which was troubling me during my walks to the temple. It was there she met her uncle, Shivdev Singh Bajwa, who was a doctor in the medical college camp set up for refugees. I saw a white nurse attending to my wound, as she was married to an Indian doctor and had not moved out of Punjab. The scar of this healed wound is still intact and I use it as an identification mark in my passport application. I have some vivid memories of the refugee camp. We used to sleep on the floor of a veranda and play in the grounds in front of Khalsa college building. Once, I was almost crushed in a melee when I took courage to snatch a *khadi kurta* (cotton shirt) from the camp where a free distribution of clothes was going on. My mother kept it as a prized possession for many years.

From Amritsar, our family moved by train to Sangrur where my father's business partner, Ajmer Singh, was living. On the way, we had to change the train at Dhuri junction. We all young children were feeling hungry. The family had some Punjabi *parathas* (stuffed bread) but they forgot to deliver our share during its service. Mother was annoyed and started weeping. She had a four anna (25 *paisa*) coin and purchased *puri-chana* for me from the hawker on the platform but kept herself hungry as a mark of protest. We stayed for a month in Sangrur before moving to a village Duladi on the outskirts of

Nabha city. My father was allotted a piece of land in this village on a temporary basis in lieu of our landed property left in Pakistan. Life was returning to normal but my schooling remained disrupted till the end of 1947.

Our family of seven had survived the onslaught of the partition of India. My mother was not feeling comfortable to live with my stepmother in the same house. She was worried about the safety of her parents as there was no news of their safe arrival in India. Just as a bolt from the blue, mother met a convoy of bullock carts loaded with refugees and moving on the road passing through Duladi. They revealed that her parents (my *Nana* and *Nani*) are safe and settled in a village near Malerkotla. I have no inkling how my mother could send an errand to her parents by this convoy. After a few days, my *Nana* and *Nani* arrived in a *Tonga* and pleaded with my father to send both of us to their village Chhokran, near Malerkotla. After a tortuous journey by tonga and on foot, we reached Chhokran late in the evening. My *Nana* and *Nani* were staying in one room provided by the family of Narinder Singh Bajwa, who brought them on his bullock cart to India after partition. They were provided food and shelter by this noble family. My mother and I enjoyed their hospitality for almost two months before moving to our newly allotted house of a Muslim family which had moved to Pakistan.

Memories of My School Days: The year 1948 was another trial for our family as a survival of the fittest. There was no source of income to make both ends meet. It was winter time and my mother started weaving sweaters for the family of rich landlords of a neighbouring village, Moranwali. In February 1948, I was admitted to the primary school in Lasso at a distance of three kilometers. That is how my teacher-in-charge recorded my date of birth as 23rd Feb. 1942 and entered it in the admission register. Our family situation improved after two

years when some landed property was allotted under refugee claims settled by the revenue department. I still remember our prize possessions were a goat and a hen during these years. Once while grazing the goat along with my *Nani*, I encountered a big snake that was about to attack our goat. After this episode, my mother never allowed me to go for grazing the goat.

My mother took a lot of interest in my education. She used to teach me Punjabi primer at home. I was a brilliant student and avoided playing games and gossip during school hours. It was a one-teacher primary school. After a year, our school teacher, Raghbir Singh Bajwa, was transferred to Bhurthala Mander and all students of our village Chhokran decided to move from Lassoï to Bhurthala. It added four extra kilometers to our daily to and fro journey. Considering my brilliant performance in studies, my teacher proposed to my mother that I should appear in class 3rd and 4th examinations simultaneously. I scored positions among the top three in both these examinations. This routine continued until I passed the middle school examination in 1955.

I will like to recount some interesting episodes of my student life during the primary and lower-middle stage. Perhaps, ours was the only school in the district Patiala, running up to the 6th class, called lower-middle school. Our school route was along the bank of a canal. There was no source of drinking water, except the Persian wheel or the canal water. Even the hand pumps were not in vogue. We had to depend upon the supply of canal water when thirsty. During summer months, our ringleaders used to pluck melons and watermelons from the fields on our route and throw these in canal water for cooling. That was a source of food, water, and fun during my school years. Sometimes, we were caught by the owner of the melon field and suffered verbal abuse in abundance or punishment by the teacher on the basis of the complaint made by the owner.

I was a timid boy and avoided the misadventures of our ringleaders. The school teacher relied on my witness in such cases which provoked my schoolmates to act against me for speaking the truth.

Those days, teachers were following the diktat “spare the rod and spoil the child”. The punishments were severe even for petty lapses. On every Monday, during morning prayer, a teacher used to check if the nails were properly trimmed? The defaulters were given a beating with the rod or a few slaps on the cheeks in front of all classmates, which was highly undignified and humiliating. The worst used to happen during classes of English grammar or Mathematics. The teachers of my school days were not less cruel than the Indian policemen of today.

We were scared of stray dogs and bulls roaming on our way to school. Once, I was bitten by a rabid dog in my village, which had to be killed, and I suffered the pangs of undergoing fourteen injections in the stomach in those days. We were afraid of passing near cremation grounds during late evenings or nights. The rural folks believed that ghosts roam in the neighbourhood of cremation sites and could frighten the passersby. We never had an encounter with a ghost but a madman, called *Mast* of Latmajra village, who scared us when we were alone on our school route. He was always found running with unkempt hair and unusual behaviour. We used to hide among the bushes on seeing him from a distance.

In 1953, I joined Khalsa High School Lasso in 7th class. During 8th grade, I purchased a new BSA bicycle from Ludhiana city and started my journeys to meet my relatives and for shopping in Malerkotla. Master Harbhajan Singh Virk, my distant cousin from Kamoke, suggested that I must join Government High School Malerkotla where the choice of the subject combination of Science and Drawing was permitted.

His argument was that it will stand in good stead for joining an engineering college or polytechnic for my future professional studies. I had to cover 20 kilometers daily on a *katcha* (dirt road) road to study in this school of his choice. This change of school proved beneficial and I topped in both ninth and tenth classes of High School. My score in both English and Maths. was around 90 percent in 9th grade and an enquiry was held by the headmaster to determine how a rural lad can score such high percentage of marks in English. My written English was flawless though I cannot claim to speak this language correctly even today. I studied Science in English medium but my performance was not up to the mark. The same was true for Drawing where I failed to get even 60 percent marks. I missed the merit position in High School and remained content with topping in an urban school.

There was no electricity in my village or in my school. During summer, we used to study under the shade of trees and during winter under the sun. Village sports like 'hide and seek', playing cards, and many more which are now extinct from Punjab rural life were our pastimes. *Kabaddi* (a rural game in Punjab), Football and Volleyball were also popular sports in my village. Our village team in *Kabaddi* and Football was a winner at the district level. I was fond of playing Football until my high school. The village tournaments were a great attraction and a source of enjoyment for me. Cattle grazing was a part of my duty and most of our rural students had to help the family in other chores of agricultural activity, like planting seedlings and cutting fodder from the field.

I also participated in village fairs (*melas*). The most famous *mela* was organised in a small town Jarg, about 7 kilometers from my village. Petty criminals used to rule the roost at these *melas*. It was usual for the police to disperse the *mela* before the sunset. Once during such dispersal, I had to run for safety and

my shoes were lost in the melee. Religious congregations were annual features of rural life. My *Nani* took me to the martyrdom day celebration of younger Sahibzadas (sons) of Guru Gobind Singh at Fatehgarh Sahib in 1951. It was a cold winter night of December and we kept awake during the night for listening to *Dhadi Jathas* singing ballads of heroic deeds of Sahibzadas. My fascination with Sikh history is a consequence of my participation in these religious conferences.

Glimpses of My Paternal Family: I was born and brought up in my *Nanke Pind* (maternal parental village) due to reasons explained in the beginning of this chapter. In my paternal family, my grandmother (*Dadi*) was of a dominating nature. Despite her physical handicap, she kept my mother under her thumb. My father was a shy and timid person and he always obeyed diktats of my *Dadi*. My role model was my *bhua* (father's sister). She was married to a veterinary doctor, Amar Singh Goraya, educated in Lahore. When my father married a second wife, my *bhua's* husband declared that he will follow suit. Despite being a father of five children, he married a beautiful, young divorcee from a Sandhu family of Dholpur state in Rajasthan. My *bhua jee* was so much upset that she never saw the face of her husband again while he was living. She started living with my paternal family to bring up her children.

My *Bhua* was a lady of iron will. She became my role model in later life. She did not ask for the divorce and refused to get any financial support from her husband. Without telling my father, she got admission in Govt. Girls High School, Kamoke in the fifth class. At the time of her marriage, she had only a primary school education. The strange thing in this whole episode was that her daughter was studying in the same school and in the same class. This fact was told to me by Mrs. Kirpal Singh, wife of the renowned Sikh historian, who was a school teacher and taught her in the middle classes. After partition,

Bhua migrated to India and settled in Nabha city. She joined Basic Training College, Faridkot and got training for becoming a school teacher. My father was against her education but she was a bold lady who wanted to live life on her own terms. Her family members may have forgotten her sacrifice but she was a living idol for me and my mother.

My mother was sent to her parental home when my father decided to marry a second wife from a Dhillon family. The reason offered by my *Dadi* was simple. My mother gave birth to three children all of whom died at a very young age. The family wanted a male heir to save their inherited property. I was born after the second marriage of my father. Just to console my mother, sometimes, my *Dadi* made excuses that my birth got delayed otherwise there was no need for a second marriage to save inheritance.

My mother took it in her stride and never raised objections against the second marriage of my father. After my birth, she started living separately on her own to avoid jealousies of my step-mother. My step-mother gave birth to four sons and one daughter, the eldest was one year younger to me. When I was school going child, my *Dadi* wanted to keep me separate from my mother which we both resisted. They were afraid of my mother's influence on my personality. In summer vacation, I used to visit my step-brothers. There was no animosity among us brothers but they were conscious that I am not their real brother.

Till my *Nani* was living, we had been enjoying life in a rural community and never bothered to seek any financial help from my paternal family. I was a good student and always got a position among the top three in my school and college days. After the death of my *Nani*, we were reduced to the state of utter penury, as elaborated in the next chapter. Despite all these difficulties, we both stayed in my *Nanke Pind*, Chhokran. My

father was supporting a big family and being a miser by nature, agreed to finance my college education reluctantly. I had to live from hand to mouth during my High School and College days. This situation changed after I passed my M.Sc. Physics examination from AMU Aligarh in 1963 and got a job to support my mother and me.

My Marriage, a mere Coincidence: It is an interesting story to recall how I was trapped in the marriage proposal. My step-mother visited my village Chhokran to participate in the death (*bhog*) ceremony of a close relative in April 1964. She took me into confidence to visit Chandigarh for the purpose of looking up her cousin from a distant relation. It was examination season and I was visiting Chandigarh as an examiner in Punjab Engineering College (PEC) in the last week of April. My step-mother had already reached Chandigarh in anticipation of my visit. One day, while I was conducting the Practical examination in PEC, my would-be brother-in-law, Paramjit Singh Dhillon, arrived with an errand from my step-mother to see her in the evening in Sector 18. It was just a formal meeting with the Dhillon family living in Chandigarh.

This process continued for a few days. During my second visit, I saw a crowd of young ladies, who were cousins to my would-be fiancée, from Bassi Pathana with their father waiting for my arrival. I could guess that there was something fishy in this whole affair. My step-mother introduced me to all the guests and asked for my opinion about the girl to be proposed for my betrothal. I had seen the girl casually while entering the house for the first time but had no meeting with her for the purpose of marrying her. I told them that I am not prepared for accepting this proposal unless my mother approves the choice of a girl being proposed for my betrothal. My would-be father-in-law agreed with me but my would-be mother-in-law was a dominating lady who forced him to keep quiet. On the third

day of my visit, I was made to sit down among all the guests and a *laddoo* (a type of sweet) was thrust into my mouth for celebrating the proposal for my marriage. I was assured that the final engagement ceremony will be held with the explicit approval of my mother.

The same evening, the family of the girl invited me to join for a cinema show to see some film. During the last three days, I had not spoken a word with my would-be life partner. I had not dared to see her from a close quarter. During three hour long show, I did not exchange a single word with her in the presence of her family. I was not only shy but a timid young man who never befriended any girl in my school or college days. I guess most of our rural youth fall in my category.

I believe it was my fault. I was still double minded. Coming from a rural background with a *katcha* (mud) house, I was dazzled by the sprawling *pucca* house of my would-be-in-laws. Before my departure, my father-in-law proposed to arrange a meeting with her daughter to remove my inhibition but I denied to meet her. I thought it is not yet my final decision to accept the proposal. On the last day, I came to meet my step-mother and to pay a courtesy visit to her hosts in Chandigarh. I was surprised that my would-be mother-in-law insisted to accompany me to Ludhiana to meet my mother and to persuade her to accept this proposal. My mother was a simple lady who was taken in by surprise by mother-in-law's visit. She scolded me later how could I accept a proposal for the marriage from relatives of her *saunkan* (rival).

My engagement ceremony was held sometime in September 1964. I was teaching in Guru Nanak Engineering College, Ludhiana. My brother-in-law came to visit us after a year but I was reluctant as yet to go for marriage. I was preparing for the Indian Administrative Services (IAS) Examination and made an excuse to postpone it. There was no communication

from both sides. My father-in-law wanted to fix the marriage as two years had passed since our engagement. He issued an ultimatum to accept the proposal for early marriage without any further delay. My mother finally came around to celebrate my marriage. It was fixed on 28th September 1966 in Chandigarh. It was a simple ceremony without much pomp and show. My marriage party included our relatives from village Chhokran and my colleagues from Punjabi University, Patiala. But basically, it was a rustic marriage.

My wife, Ranjit Kaur Virk, made adjustments in my family. She gave birth to three sons, raised my family in the best possible traditions, and made her presence felt in the socio-cultural organisations of universities where I served. She proved to be more tactful than me. My mother was pleased that she was blessed with three grandsons. But she was never reconciled with my choice from the core of her heart. Once, she remarked that her *saunkan* (rival) kept her out of her husband's house for the whole life and now my wife may keep her on tenterhooks for the rest of her life. I feel she was not absolutely wrong in her assumption. For me, life has been a compromise and a game of dice. I believe in the dictum that marriages are made in the heaven!

□

Chapter 2

My Student Life: Up Against Odds

Life has neither been a bed of roses for me, nor I was born with a silver spoon in my mouth. My father owned both landed property and some business in Kamoke town but I had no truck with his business. He inherited five *murabbas* (squares) of land and cultivated paddy crop of superior quality (*Basmati* rice) for export. From the profits made by selling *Basmati*, he invested in a rice sheller and a wood cutting bandsaw machine. Before I was born, he married a second wife in 1940. My mother chose to live with her parents as she was not inclined to tolerate her rival in the bigamy. My mother's parents were not very rich but they had enough land to support both of us comfortably.

My Story of Trials and Tribulations: My *Nani* had no mail issue. When we started living with *Nana-Nani*, some of the collateral descendants (*shariq*) thought the ancestral property will be inherited by me; hence they started conspiring both against me and my *Nana-Nani*. My *Nana* died in 1952 and the ownership of land was transferred to my *Nani* under the inheritance act. During 1953, an attempt was made to kill my *Nani* by throttling her when she was visiting her farm in village Chhokran. But she survived this attack due to her good luck.

In April 1955, I had joined Govt. High School Malerkotla in 9th class. On 7th May, my *Nani* was killed by a lineal descendant (*shariq*) who had earlier throttled her in 1953. The major portion of our land was being cultivated by Gurdial Singh Bajwa and some 4-5 acres by Darshan Singh Jathol. On the fateful day, Darshan Singh called my *Nani* to lift her share of

the wheat crop sown by him. When she reached the farm late in the evening, a young man named Shinda from her collateral descendants was lying in ambush, and she was killed on the spot. We learned later that both Darshan and Shinda had conspired to kill her. The news of her death was conveyed by Gurdial Singh to my mother. She got this stunning news and called me home from the playground. Clutching me to her bosom, mother told me while sobbing “My son your *Nani* has been murdered”.

I was a young boy of thirteen and this shock was unbearable for me. The ladies from the neighbourhood assembled to console my mother and me. After some time, the headman (*Lambardar*) of the village came to our house to start the search for the dead body. I was accompanied by Nasib Chand and some other friends from the village and we started marching towards our farm where the dead body was supposed to be lying. It was pitch dark when we reached that spot but there were only traces of blood but not any dead body. We started guessing about its disposal by the killer but failed to find any clue. Our search was futile and we returned to the village around 10 PM.

Around midnight, there was a knock at our door. The village watchman (*chowkidar*) was calling us to join for the search of the dead body as the head constable (*hawaldar*) of police had arrived from a neighbouring village to help us. We returned when the second attempt for the search of the dead body proved futile. However, at daybreak, the search team found some clues that the body had been thrown in an abandoned well adjoining our farm. The dead body wrapped in a gunny bag was fished out of the water by a diver and brought to the village compound. The police called some eyewitnesses and recorded their statements. A pall of gloom had descended on the village and I could not bear the sight of the cut out throat of my

Nani. After some time, a bullock cart was arranged for the transport of the corpse to Malerkotla for the purpose of the post-mortem. Bahadur Singh Kahlon, a cousin of my *Nani*, accompanied us to civil hospital Malerkotla for this purpose. We returned after sunset and the cremation was arranged hurriedly in the *shamshan ghat* (cremation ground) outside the periphery of the village.

The court proceedings were conducted in the court of Judicial Magistrate at Malerkotla in the case of murder. We engaged Harbans Singh Sherwanikot as our lawyer. My mother and myself were called into the witness box to record our evidence. Two other eyewitnesses, Gurdial Singh and Hazara Singh, appeared in our favour. The other party arranged a criminal lawyer, Karam Singh Nagra, from Patiala who cross-examined us in the witness box. It was a harrowing experience for both of us, my mother and myself. The case moved to the sessions court in Barnala for final judgement. We engaged Surjit Singh Barnala as our lawyer on the day of arguments. In fact, we had no money left to fight this case and as expected the judgement was delivered in open court in favour of the other party. The murder accused was released on the basis of poor defence and lacunas left by the police in filing the first information report (FIR).

We were reduced to a state of penury in fighting this case. We were dispossessed of *Nani's* land holdings and our standing crops were captured by the murderer's party. We had exhausted all our resources during this case. I had no money left to purchase my books. My mother's relations provided some support in the form of wheat grains to keep our kitchen running. I did not ask my father to provide any financial help. My teachers and classmates proved to be a great source of strength. I used to borrow my textbooks from both and returned the same after reading. During both these years of high school, I had hardly

any textbook in my personal possession except a textbook of English provided by my teacher as her complimentary copy. Despite these handicaps, I scored the top position in the 9th class in the final examination.

After the murder case in 1955, we were involved in the litigation which lasted almost for a decade. Since the murderer of *Nani* was roaming free after his release, we had to seek his bail for our security. It was a tedious process. First, we had to establish that there was a real danger to my life by creating some true or false situation. The police then came to arrest the other party. Police expected bribe from both the sides. After court proceedings, the other party was released on bail bonds (*jamanat*) as surety for our safety.

In 1956, Hindu Succession Act was passed by the Indian Parliament. As a consequence, my mother filed a court case to inherit her mother's property under this act. It was our good luck that after a long drawn out battle in lower and higher revenue courts of Punjab, my mother won the case of inheritance. We both had to attend courts in Sangrur, Patiala and Chandigarh for keeping our hopes alive. I cycled almost 90 kilometers to and fro to Sangrur to attend court proceedings every month. The civil and revenue cases drag on for years without an end in India. I never allowed my studies to be interrupted or disrupted due to the court cases.

My teachers took a lot of interest in my studies. Harjit Singh Rai taught us Mathematics and Science during high school. I was offered free lodging and boarding facilities in his house for a month on the eve of Matriculation examinations. His wife treated me like her son offering me homely comforts. My life-long relationship with Rai family is still intact. Presently, they are settled in Calgary, Alberta, Canada. The school teachers expected that I shall score a high merit position in the Matriculation results of Punjab University, Chandigarh. I was

not so keen to watch my result and continued grazing our cows the day results were declared. The milkman of our village, Sadhu Singh Virk, brought the news from Malerkotla that I have topped in my high school but failed to achieve a place in the merit list.

The Story of My College Life: The college admissions started in mid-May. I was interested to continue my studies in the non-medical group of F.Sc. (Intermediate). When I asked my mother about the college admission fees, she presented me a note of ten rupees, which was all in her possession. Mother advised me to seek help from my father but I ignored her suggestion. Darshan Singh Grewal, a science teacher in Islamia High School, Malerkotla and living in my neighbourhood, was my constant sympathiser and motivator during these days of adversity. Somehow, he came to know of my predicament. He offered to pay my admission fees as a gesture of goodwill. However, I was reluctant to accept his offer.

Next day, I reported the situation to my school Headmaster, Raghu Nath Sahai. He was so much impressed by my entreaty that he accompanied me on his bicycle to the office of the Principal, Government College Malerkotla. Mr. Sahai told Mr. Khosla, the Principal, that I was a rural student who topped in Govt. High School and deserve full fee concession. This kind-hearted Principal not only waived all my admission fees but also sanctioned some money from the amalgamated funds of the college for the purchase of my books. The only condition imposed was that I had to return the books to the library after my examinations were over. My mother was overjoyed to learn about my admission and she went to the village Gurdwara to offer her special prayers of gratitude.

Govt. College was set up by the Nawab of Malerkotla as an intermediate degree college before the partition of India. It

was upgraded to a full-fledged degree college in 1955 under the PEPSU regime. During my college days, the number of students was less than 400 and the college was catering to the needs of rural areas of the neighbourhood. All the teachers and students rode their bicycles to reach the college. I was lucky to have one for my rides. There was no dress code for either students or teachers of the college. I was not in a position to afford the costly and fashionable dresses. My choice fell upon rough *kehad*i wear prepared by my mother using home-spun cotton. In college days, I was a sort of rebel caring nothing about my social status but only focussed on my studies. I acquired the habit of preparing my lessons in advance. I covered most of the chapters of my book on Trigonometry during summer vacation. Even while grazing cattle, a pastime for us rural students, I kept a book in my one hand and the 'grazing stick' in the other. I had no time to waste. My engagements were heavy and the conflicts became part and parcel of my early life.

I was hard pressed for time. Despite these handicaps, I secured the second position in the first year house tests and final examination of my college. Except for English, I attained 2nd position in all Science subjects and top position in Punjabi optional. I was awarded a set of six books during annual prize distribution of college. The book which inspired me to opt for Science as my career is still in my possession. It was a popular science book "The Universe and Dr. Einstein" authored by Lincoln Barnett. This book was my first introduction to Theory of Relativity and four-dimensional continuum of Space and Time. I was motivated to interpret the *Gurbani* of Sikh scripture later on, for example, the topics of Cosmology and Nature (*Qudrat*), scientifically based on my early studies of this book.

I was not pessimistic in college life but up against all odds. I learned to cope with my circumstances thinking that it was

my testing time and a temporary phase of my life. My routine started early morning much before sunrise both during summer and winter. After ablutions at the village Gurdwara *kehuhi* (a small well), I attended to morning prayers and when the *Granthi* (the reader of the Sikh scripture) was on leave, I conducted the morning service and prayers. This gave me the strength to stand firm in the face of adversities of my life. My mother was a daily reciter of *Nitnem Banis* but I recited only *Japuji* which was committed to my memory in school days. After college hours, I cycled back to my village and attended evening prayers in Gurdwara. Occasionally, I joined Darshan Singh Grewal to recite the evening prayers (*Rehras*). After early dinner, I studied under the dim light of a lantern. During the rainy season, it was a horrible experience to deal with moths surrounding my lantern. During examination days, mother made me wake up before the crowing of a rooster (*murge di bang*) at 4 AM, which was used as a timekeeper, in lieu of a clock, by the village folks in my college days.

Professor Bahadur Singh taught me Physics, B.K. Chaudhary, Mathematics, and Balbir Chand Verma, Chemistry during my F.Sc. Bahadur Singh took a special interest in tutoring me as he was sympathetic towards the rural boys in his class. The most popular teacher was Nirmal Singh who taught us English. He made the subject interesting by narrating episodes from English literature. He used to remind us of the laws of physics as he was a B.Sc. pass. I memorised all the poems from my English poetry book. My classmates took tuitions and started cramming before the final examination. I was not used to cramming but believed in reading, writing and revising my lessons. In the final F.Sc. examination, I missed the merit position by seven marks. Bahadur Singh encouraged me to go for Engineering studies if my resources permit.

I applied for admission to B.Sc. Engineering in Thapar

College, Patiala. I was placed on the waiting list. I was surprised that in the first list, only merit holders of F.Sc. qualified for the admission to Thapar College. It was the end of July 1959 when I applied for admission to B.Sc. (non-medical) in Mohindra College, Patiala, without waiting for the second list of Thapar College in which I was sure to be selected. My father agreed to support me reluctantly for higher studies. I joined college Hostel for my residence as my village was at a distance of 60 km. from Patiala. Every month, I started getting Rs. 50 by money order from my father. I had to pay my tuition fee and hostel expenses out of this meagre sum. Since I was living from hand to mouth, I started looking for private tuitions. The first offer came from Padam Swarup, the head of the Physics department in Mohindra College. I was coaching his son in Science subjects. Soon my reputation spread and I was engaged to teach Punjabi to the daughter of a Professor in Thapar College. My income from these tuitions was matching with what my father used to pay.

Mother needed some help for her survival in the village. I used to cycle down 60 km. on weekends from Patiala to my village Chhokran. I was homesick during the first year of my stay at the Hostel. At the time of my first departure to Patiala, our emotions were running high and we both started weeping. Later on, we both reconciled to the situation. My living style remained the simplest possible. Instead of *khadi* wear, I started wearing *kurta-pajama* combination and Punjabi *jutti* (shoe) of Patiala make but pant-shirt was not yet part of my choice for a dress. I qualified in my B.Sc. final examination with first division and distinction in Physics. My father proposed that I should join as a Science teacher in some high school. He told me by earning B.Sc. degree, I had become the highest qualified person among our Virk community of Kamoke.

The Story of My University Life: My adviser, Prof. Bahadur

Singh, recommended that I must go for a Masters degree in Physics. It was a hot summer time when I started looking for financial support from my relatives riding hundreds of kilometers on my bicycle. My *Nani's* brother returned just 100 rupees out of Rs. 200 borrowed from her sister at the time of his marriage some twenty years ago. Ultimately, my father agreed to provide help for my higher studies. My stipend was raised from Rs. 50 to Rs. 100 per month. I packed my bag and baggage and boarded the train from Patiala to Aligarh travelling by third class to save money. Reaching Aligarh, I moved in a cycle rickshaw to the residence of Prof. PS Gill, head of the Physics department in Aligarh Muslim University (AMU), Aligarh.

I had an appointment with Prof. Gill at 4 PM. I told him about my plan to join M.Sc. Physics course in AMU. Gill dissuaded me to join AMU and suggested that I should seek admission in Benares Hindu University (BHU) Varanasi or some other University. The reason offered was simple: Gill was going on sabbatical for one year to the USA and most of the competent faculty had already left AMU. I felt discouraged and sad. Just while I was coming out of his residence, I encountered an unknown Sikh gentleman riding on his bicycle. He was Bhai Amar Singh, President of UP Sikh Mission with headquarters at Aligarh. He accosted me and offered to look after my problems of admission in AMU. In fact, he was a member of the University Senate and knew all officers including Prof. Gill. He took me to the residence of Dean Science Faculty, who convinced me to join AMU. I wonder how chance encounters with strangers played a sterling role in my life. For two weeks, I enjoyed the hospitality of Bhai Amar Singh and joined AMU as a student of M.Sc. Chemistry under the faculty of Science.

My aim was to study Physics but I was admitted to M.Sc.

Chemistry in AMU on the basis of merit. This was another setback to my plans. I wrote a letter to Prof. Bahadur Singh about my predicament. He advised that I should continue my studies at AMU. After a week, I came to know that two second division students from Punjab, Santokh Singh Nagi and Jagrup Singh, had been admitted to M.Sc. Physics. I rushed to enquire about it wondering why I was not called for the interview? In the absence of Prof. Gill, Harnam Singh Hans took over as the head of the Physics department. He checked my credentials and offered me a seat in M.Sc. Physics. I migrated to my favourite subject with the permission of Dean science faculty, whom I knew well from the day of my arrival in AMU. For my residence in AMU, I was allotted a room jointly with three other students in Jamal hostel of Minto Circle.

My choice to join M.Sc. Physics in AMU Aligarh was based on two considerations: (i) Presence of Prof. Gill, a world-renowned Cosmic Ray physicist, and (ii) AMU was providing the cheapest education in India. But as Prof. Gill had warned me that competent faculty had moved out of AMU, I could feel its impact on my studies. I started feeling that Physics was a hard nut to crack for me. My introvert nature caused immense problems for my adjustment in AMU. My roommates were polytechnic students in AMU and smokers by habit from some rural area of UP. It was disgusting to stay with smokers, hence I had no option but to change my room. Most of my time was wasted due to this adjustment in the hostel. In October 1961, riots took place on AMU Campus and we were asked to vacate hostels. Our studies were disrupted for nearly a month and I moved to Punjab for a break.

The first year M.Sc. results were disappointing. I could secure pass marks only having failed to qualify in Mathematical Physics. More than 50% of my classmates dropped out of the examination due to tough paper but I could not afford to lose

one year of my academic life. After the examination, I returned to Punjab and started teaching Science in Khalsa High School, Lassoī during my summer vacation. Before my return to AMU in July 1962, I visited Prof. Bahadur Singh in Mohindra College Patiala for consultations in face of poor prospects in my M.Sc. Physics. He narrated his own experience at BHU during M.Sc. studies. He secured third division in the first year of M.Sc. but passed out with first division in final year M.Sc. Physics. I was convinced that I can repeat his performance with perseverance and change the future course of my life.

Prof. Gill returned from the USA after spending his sabbatical and started teaching us special elective paper “High Energy Physics”, known as Elementary Particles in common parlance. I was motivated more by his personality and less by his teaching. He used to narrate his experiences of discovering the Cosmic Ray Latitude Effect and his investigations into the spin of Mu-mesons by high altitude experiments carried out in the Himalayas. The final year of M.Sc. was relatively peaceful in AMU, my adjustment was not a problem and I followed the advice of Prof. Bahadur Singh to prepare well for my examinations with a targeted study. When the results were declared, I had secured first division in M.Sc. final examination. On 13th April, Vaisakhi day, I returned to Punjab to join my mother after a lapse of six months. I joined my old school as Science teacher @ Rs. 150 per month salary to get rid of the financial crunch in the family caused by my higher education in AMU.

Just when my results were declared in May 1963, we received the court order in our favour, declaring my mother as the rightful inheritor (heir) to her mother’s property. A ray of hope appeared in the gloomy life of my mother. We kept this good news secret for many days to avoid the jinx. I left my school job to devote more time in running after police and

revenue officers for taking possession of our landed property after a long drawn out struggle extending over eight years (1955-63). Our coparceners appeared on the scene to ask for their share. My mother and I fought this battle alone but did not want to keep them out. They shared the expenses of litigation after our victory. I met the SDM Malerkotla, Anokh Singh Powar, who promised all help provided we donate some land to the welfare of defence personnel. Despite his support, the police forces kept us on tenterhooks and possession was not delivered to us despite the transfer of property rights to my mother.

There is a famous proverb in Punjab that a *Jat* will die but not transfer the possession of his legally or illegally acquired land. Police and revenue authorities completed the formality of transfer of land to my mother but both times the other party got it vacated by force and muscle power. It was in the air that they can commit my murder and that of my mother to inherit the land. This came to happen soon during my stay in the village but I was saved by providence.

To get possession of our land, I started contacting my old classmates and friends of school days. Amar Singh Tiwana and his brother Lachhman Singh from Lassoï came to our help. Prahlad Singh from AMU Aligarh returned to his village Malmajra, near Samrala. He brought his tractor to help us in ploughing our land. The day I went to invite him for this purpose, I was spotted by the man who had murdered my *Nani*. On my return journey, I got the inkling that the guy can cause harm to me. By good luck, I changed my route from Khanna and instead of coming via Jarg, I took the longer route via Payal. Just before I returned to my village, I met Master Raghbir Singh who was requested by my mother to track me down. Master Jee informed that I had come out of the jaws of death safely by changing my route otherwise the guy had laid a trap

to capture me over the notorious *Jaure Pul* (twin bridge) with a killer instinct. My mother, a firm believer in the hand of God, prayed for my safe return and forbade me never to take such risks.

In July 1963, I was selected as a Lecturer in Physics at Lyallpur Khalsa College, Jalandhar. I had no teaching experience and handling a class of 90 students was a big problem. Once I was so much annoyed by the behaviour of students that I got hold of a ringleader and pushed him out of the classroom holding him by the neck. I almost lost my temper and rebuked the class. Next day, Principal Ram Singh came stealthily in my class to see how I teach Physics? After the class, he called me to his office and appreciated the way I teach. But he advised me to handle the ringleaders with a tactic and not harshly as I did. I was informed that the students had complained to the Principal about my teaching method.

In September 1963, I resigned from Khalsa College Jalandhar and joined Guru Nanak Engineering (GNE) College, Ludhiana at a higher salary. I heaved a sigh of relief as this college was being run under the rigid discipline of Principal Tara Singh Randhawa. I started teaching Applied Physics to the first year B.Sc. engineering graduates and became one of the most popular teachers in the college. I could recall by name all the students of my class without looking up the attendance register. This college caters to the rural students since its inception and I developed an intimate relationship with them instinctively. I was also paid an extra salary for teaching AMIE classes and part-time diploma classes in the college. I was living in a rented room in Model Town, Ludhiana and my mother joined me to help in the upkeep of my living room and cook my food.

It was my dream to serve in this professional college but after two years I realized that teachers of engineering stream

considered Applied Science teachers as the second rate. I was determined to leave it when the opportunity came my way. Punjabi University Patiala advertised teaching posts in July 1965. I was selected as Instructor in Physics department. I reported myself on duty on 15 October 1965. Physics department was operating from the Thapar College before moving to the new campus of the university on Rajpura road. Before I moved to Patiala, we took possession of our land with the help of Anokh Singh Powar, SDM in Malerkotla. I consider my status after joining GNE college helped me to be assertive with dealing officers, which mattered a lot.

My student life from High School to AMU Aligarh has been full of struggle. I wonder how could I come out of this struggle unscathed? I was almost fed up and wanted to wriggle out of this trap. Our land was being cultivated by my relatives and coparceners. Out of the first year's sale proceeds of our crop, I purchased a Jawa motorcycle for my ride to GNE college. A freak accident happened on our farm towards the end of 1964. My cousin, Mohinder Singh Kahlon, was electrocuted by a live high tension wire while he was ploughing his field. Our hopes of keeping the farming activity alive were shattered by his death. We decided to sell our landed property in village Chhokran. It was a sale deed done in the panic, hence we collected less than one *lakh* (hundred thousand) rupees for a big chunk of fertile land. Today it could fetch more than ten crores!

As they say "All is well that ends well". After selling our landed property, I built a house in Model Town, Patiala. Peace returned to our family as a gift from God. My focus was shifted from litigation to teaching and research. I remained committed to my mother for the whole of my life. The dangerous phase of my life lasted for almost a decade (1955-65).

□

Chapter 3

Memories of Punjabi University Patiala and Paris

I joined Punjabi university Patiala as Instructor in the Physics department on 15 October 1965. This university was created under an act of Punjab in 1962 for the development of Punjabi language and its promotion as a medium of instruction for all subjects including Sciences and Humanities. During my interview, I was first asked some questions from my field of specialisation and then the most important one about my capability to write textbooks of Physics in the Punjabi language. I had two years teaching experience in an engineering college but what clinched the issue in my favour was the publication of two poems in Punjabi in a famous magazine “*Kavita*” (Poems) from Amritsar. I started teaching a course on Heat & Thermodynamics and guided an M.Sc. thesis “Elementary Particles” during the 1965-66 academic session. I rented an accommodation in Model Town Patiala which was close to the Thapar College, Patiala.

The university started functioning in 1963 with its offices in Baradari Gardens and teaching classes in Mohindra College, Patiala. Physics and Chemistry classes were being run from the campus of Thapar College, Patiala. When I joined, the first batch of M.Sc. Physics had passed out. Initially, HR Sarna and PK Kitchlu, both ex-professors of Punjab University, Lahore, were hired to set up the new department but when I joined, Dr. Baldev Singh Sood was Reader and Head of Physics Department. Dr. Charanjit Singh Khurana, who had been my teacher in AMU Aligarh, was working as a Lecturer in Physics. In fact, I was motivated by Dr. Khurana to join this university

when I met him once on my visit to Patiala. In addition to these two Ph.D. teachers, there were eight instructors, all non-Ph.Ds, who were sharing the bulk of teaching responsibilities.

In July 1966, Physics department was shifted to Punjabi University campus on Rajpura road. Kirpal Singh Narang was Vice-Chancellor of the university who had served Punjab University Chandigarh as Registrar. He was responsible for setting up new departments for development of Punjabi and creating infrastructure for teaching and research in Science departments on the new campus. After one year, I was allotted a two room accommodation in Teachers Flats on the campus. I must consider myself lucky that I have been privileged to live on campus for my entire teaching career in the university. It was a great advantage for my family and myself to enjoy the clean environment of the university campus and avoid the risky travel to and fro from the city to campus when means of transport were very limited and primitive. University bus service was not adequate to cope with the rush of students and employees, and only some respite was provided by the PEPSU Roadways service.

My teaching assignment was not heavy and I could do some other academic work for the university. I was teaching Special Theory of Relativity and Particle Physics to M.Sc. students. My notes on the Theory of Relativity became so popular that I planned to write a textbook. Cyclostyled notes were provided to students but the head of the department did not approve of it. Hence my plan to publish my textbook was also dropped. My assignment of teaching a special paper “Cosmic Rays and Elementary Particles” was withdrawn after a year as the result of my section was not up to the mark. The system of external examination in our universities had been a major drawback in our education system. I made a mistake of giving a guess paper to my students; most of the questions

were set out of the scope of this guess paper, as a result, the performance of students was below our expectations.

Punjabi University was preparing textbooks to teach Science in Punjabi medium in colleges affiliated to the University. Punjab Language Department (*Bhasha Vibhag*) and Punjab University Text Book Board were two other organisations involved in this exercise. There was an utter lack of resources such as dictionaries of scientific and technical terms in Punjabi. The university started a medium switch over programme under which a prize scheme was introduced to award prizes to the authors of Punjabi books in science. I translated “Story of Cosmic Rays” by Arthur Beiser under the title “*Brahmandi Kirna di Kabani*” in 1968 which was awarded the first prize by Surjit Singh Barnala, the then Education Minister of Punjab in 1969. Later on, I came to know that Prof. PS Gill, Director of CSIO Chandigarh, and a renowned Cosmic Ray physicist, was one of the evaluators of this book.

One major drawback in Punjabi university was recruitment of the competent faculty. Most of the teachers and heads of departments were recruited from the faculty of local colleges which had no training in research methodology. As a consequence, the research activity kept a low profile and teaching also suffered. Most of Science departments were headed by Readers and Lecturers, and not Professors, hence there was a lack of good quality leadership in the departments which is of paramount importance in the initial phase of the university. This pitfall was avoided in Guru Nanak Dev University by the wisdom of its first Vice-Chancellor, who followed the US Model of building a department after recruitment of a competent Professor as head of the department.

After five years of teaching, I became eligible for the study leave to go for my doctorate in India or abroad. Since I joined

Punjabi university, many young Instructors recruited in 1965 had resigned and joined universities in Canada or USA for doctoral studies. I was lucky to be promoted as Lecturer without a Ph.D. degree in 1966 just before my marriage. Hence, I postponed my departure to a foreign country for higher studies. University was running foreign languages programme and I had joined a French Diploma course in 1966, which I qualified in April 1967. I started learning Punjabi and qualified in Gyani (B.A. Hons. in Punjabi) examination in 1968. The university rewarded me by an advance increment after Gyani. Then, I joined Certificate course in Russian language being offered on the campus and passed it obtaining first division and a second position in the class. In a manner of speaking, I had prepared myself for studies in France and Russia both.

In 1968, Gora Lal Garg of Mathematics department was selected under the Indo-Russian exchange programme and joined Moscow State University for his doctoral studies. I was selected under the same programme in 1969 and was preparing for my departure when all of a sudden I received a letter announcing the cancellation of my trip to Moscow. I asked Gora Lal to enquire about this episode and he reported that the number of Scholarships had been reduced from 50 to 30 and I had lost my chance to study in Moscow. When I reported about this misadventure to Charanjit Singh Khurana, my well-wisher in the department, he told me there must be something fishy in this whole affair. He started alluding to my participation in University politics as I was Vice-President of Punjabi University Teachers Association (PUTA) for the last two terms. Perhaps, after selection, the intelligence reports went against me as I was an active member of PUTA.

From Punjabi University to Marie Curie University in Paris: I applied under the Indo-French Cultural Exchange Programme in 1970 and got selected for higher studies in

Physics. My interview was held in Alliance Francaise, Delhi where I scraped through French tests, both written and oral, but did very well in my subject interview. My friends on the campus remarked that losing Russian scholarship had proved to be a blessing in disguise as France was a much better choice for research and socio-cultural interactions. I met the VC, Kirpal Singh Narang, who assured me of all help. Before my departure, I had built up a house for my family in Model Town, Patiala, as I was not sure of retaining campus accommodation for my family during my absence. I applied for study leave of three years, and to my surprise, it was sanctioned with three-fourths of my salary and on the campus accommodation for my family. It uplifted my mood for some time but pangs of separation from my dear mother and a young wife with two little kids started worrying me.

Let me digress from my story of winning this scholarship. During 1970 campus elections, I was elected President of PUTA unopposed. My selection under Indo-French programme was announced just during this period. I was supported by the Progressive Front of the PUTA which was led by Prof. Nazar Singh Dhillon of Chemistry department. My opposing candidate, Harbhajan Singh Grewal, was supported by Democratic Front. To avoid conflict and division in PUTA ranks, the opposition party wanted to go for a consensus. It was decided that I should accept the position of President and Grewal will climb down to the General Secretary post in PUTA. After the election, I announced the result of my selection under the Indo-French Scholarship to study in France. It was a complex situation. My supporters wanted me to stay back to fight for teacher's cause but my VC advised me to opt for going abroad for Ph.D. Since I had lost my chance to study in Russia a year before, I did not want to take another risk. My election as President PUTA might have tilted the balance in

my favour when my study leave was sanctioned by VC with full privileges allowed under the university rules.

Before my departure to Paris, my colleagues in the Physics department did not bother to arrange a farewell party, which was the norm in the university. However, my students from B.Sc. (Honours) class managed to organise it privately without official permission. A day before my departure to Delhi, Gurbax Singh Toor and his friends invited me to the coffee house for a farewell party. A cassette player was borrowed from Parkash Singh Jammu of Linguistics department to record the proceedings. Upkar Singh, the younger brother of Surjit Pattar, the poet laureate of Punjabi University, happened to be my student. He is a good singer who rendered Pattar's Punjabi *ghazals* into music on this occasion. I was fond of writing and singing Punjabi folk songs in college days. On the request of my favourite students, I recorded some of my songs on the cassette, which I took to Paris University. I have kept it safe in my custody but the old cassette has become outdated and its conversion into a compact disk (CD) had not been possible till date. I want to keep this historical memory event for posterity.

My plans for departure were finalised for this first foreign trip of my life. My mother and wife accompanied me to New Delhi on 26th September but on reaching Air France office in Delhi, I was informed that my trip had been postponed by the French authorities without giving any reason. We returned to the university campus empty-handed. I was reminded of the Russian episode and allusion of Dr. Khurana to my participation in PUTA activities. This time I was President and my apprehensions of being under the scanner of intelligence agencies was higher than last year. A day after my return to Patiala, I got a phone call from the French Embassy in Delhi that I must reach on 9th October 1970 for boarding my flight

to Paris. On 10th October morning, my Air France flight landed at Orly airport. We were two Indians, myself and Rajeshwar, travelling in the same plane under the same scholarship. As expected in the communication from the Scholarship office, we were to be received at the Orly airport by their representative, but there was none to our utter surprise, hence our predicament where to go in Paris?

We were stranded at the Orly airport. Suddenly, we saw a bus loaded with African students ready to leave for Paris city. Without asking where it was going, we boarded the bus. It reached the city and offloaded all the students in a residence meant for African students. We were allotted a dormitory along with other students. I was not used to the western mode of toilets and bathing facilities. When I tried to open the shower overhead, I was almost burnt by its hot water as I failed to set it appropriately at the optimum temperature position. Breakfast was provided and we were instructed to reach Scholarship office for further guidance. Our problem was compounded by our ignorance of the French language. We called a Taxi and told him to take us to the Scholarship office. Taxicab crossed the office building without stopping but Rajeshwar was a clever Delhiwala, who got hold of the driver from behind and told him to turn it back. Once in office, our problems were taken care of. We were provided a month's stipend in advance, given a metro map, and other instructions for our stay in Paris.

Normally, all scholars who reach France under Indo-French Scholarship scheme are shifted to a small town Rouen, near Bordeaux, for the study of the French language. We were also provided train tickets to Rouen after a stay of two days in Paris. I was carrying a letter of introduction for Sham Lal Malick, a scientist from Nabha, who was working as a research scientist in the Marie Curie University of Paris. I asked Rajeshwar to proceed to Rouen and myself went in search of Dr. Malick.

Fortunately, he was available in his laboratory and took care of my problems in a sympathetic way. He asked me to stay back in Paris and cancel my trip to Rouen as the French language can be learned in Paris. He introduced me to his director, Professor Francon, with a request on my behalf to search for a research supervisor for me in the Marie Curie University of Paris.

I was interested to pursue my doctoral thesis in the field of Cosmic Rays. Soon after, I was lead into the office of Professor Max Morand, who was director of the General Physics Laboratory and an expert in High Energy Cosmic Ray Physics. He prepared a letter of acceptance to supervise my research leading to Ph.D. and directed the Scholarship office to transfer my registration documents to his laboratory. This letter of introduction to Dr. Malick was written by my benefactor, Prof. Harbans Singh of Encyclopaedia fame in Punjabi University, Patiala. I had gone to seek his blessings before my departure from Patiala but could never imagine that his magnanimity will save one precious academic year of my life. I joined my research laboratory within three days of my arrival in Paris without wasting one year of French language study in a remote corner of France.

I was the only turbaned Sikh in the Marie Curie university of Paris. My stay was in the Indian hostel (*Maison de l'Inde*) of International Hall where hostels of nearly 50 countries of the world were located on its campus. It was an ideal site just outside the periphery of Paris. My residence was connected with the university at Jussieu by both the metro and the bus. The time of travel was almost the same as the metro route was the longer one with two changes en route. So I preferred travelling by bus in the morning to reach my laboratory at 8 AM. My job was quite demanding. I was always the first to reach my research laboratory and the last to leave it in the

evening. Mostly, I took my dinner on the way in some university restaurant before reaching my hostel. I enjoyed walking from my laboratory to the Indian hostel, a distance of more than 4 km. in 40 minutes on a fast pace, as there was less traffic in the late evening hours. Sometimes, when I had to work on the IBM 1620 computer for analysis of my data, I preferred to stay for the night in the laboratory.

Just after two months of my stay in Paris, I had a chance meeting with another Sikh gentleman, Naresh Pal Singh, from Karnal in Haryana state. One day when I was coming out of the Scholarship office, Marianne Hook, wife of Naresh Pal, called me aloud to stop. I was introduced to Naresh who had migrated to France after his marriage with Marianne in India. Marianne was working as a Librarian in the UNESCO office in Paris. Later on, Naresh got admission to Marine Biology course in my university and used to meet me in the corridors. He was not serious in studies but joined the university only to have fun. After a few months, he made friendship with Catherine, a student of Masters in Physics in the university, who was interested in exploring the Sikh religion and culture. Sometimes, I also joined in their discussion in a Café in front of the Jussieu campus of the university. Before I left Paris, I found Naresh had developed an extra-marital living relationship with Catherine and his marriage with Marianne Hook was on the rocks.

Our mutual friendship lasted over a span of 32 years till the death of Naresh in 2002. My only pastime in Paris was weekend tours organised by the Scholarship office in the countryside. Tours to royal Castles in the Loire valley (*Chateaux des la Loire*) were most popular among foreign students. I made friendships with many Arab and Latin American students during these tours. Singing and dancing programmes were organised during these weekend tours. I gained a sort of popularity for

my folk singing and was always in demand during these tours. My meetings with Naresh and Catherine gave me some respite from my scanning work in the laboratory. Once in a while, I was invited by Lata Malick, the wife of Dr. Malick, to taste Punjabi food in her home in Paris.

Return from Paris to Patiala: After finishing my doctorate in the Marie Curie University, Paris within two years and two months, I returned to Punjabi University Patiala on November 5, 1972. I was in such a hurry to reach my home on Diwali eve that I did not inform my family of my return. I wanted to give them a surprise. I reached by Air France flight at Delhi on 5th November morning but was held up at the customs without any rhyme or reason. I had nothing costly in my baggage and was carrying only small gifts for my family but my baggage was not cleared at the customs. I was not in a mood to bribe the customs clerk and wasted so much time at the airport. Ultimately, I left my baggage with the customs and rushed to the inter-state bus stop in Delhi. The semi-deluxe bus to Patiala was overbooked and I had to hire a taxi at an exorbitant price due to Diwali rush. Just before midnight, I reached my home on the university campus when all were sleeping without an iota of information about my arrival at the university.

On 6th November, I joined my duties in the Physics department. My study leave was for three years and my Scholarship was also for the same period. There were three reasons of my early return to India: (i) My Ph.D. thesis project was over and I got the degree in a record time of two years, (ii) My professor-in-charge was on the verge of retirement, and (iii) Punjabi university had advertised Reader's post in Physics and I wanted to compete as a candidate. I fail to understand why the university cancelled the interview for the post for which I was a hot candidate? It was in the air that the interview was cancelled because a candidate working for his Ph.D. under

the supervision of head physics department for the last eight years failed to submit his thesis.

Sometimes, I was remorseful why I returned to India before my study leave ended. I could visit my family for one month and return to Marie Curie University, but this option I failed to exercise. My family insisted that I should stay in India and I had to respect their wishes. There was no infrastructure to carry on my research activity in PU Patiala. I had published five papers after submitting my Ph.D. thesis. My head of the department accosted me that one can boast of publishing papers abroad but the real test will be when you start publishing in the parent department in India. I pledged to start my research as soon as possible. The head advised me to apply for a research project to national funding agencies like UGC and CSIR. I followed his advice and wrote two projects and both were sanctioned after one year. This was the first time in the Punjabi university that a lecturer was working on two major projects. Our research group was soon in the limelight due to the highest number of publications in the annual report of the university.

Once again during 1973, I fought PUTA elections for the post of Vice-President as an independent candidate without aligning with any group. My affiliation with Progressive Teachers was broken after I left them in the lurch before my departure to France. I knew they were annoyed with me. There were five candidates in the fray and competition was very tough. I lost this election with a narrow margin to Kehar Singh. My head of the department was against my fighting elections and most of my colleagues in the department voted against me out of jealousy. I vowed never to fight elections after this defeat and devoted myself fully to academic work during the rest of my life in the university.

In addition to my teaching duties, I was a regular visitor to the playgrounds of the university. I relished playing football

and going for evening walks with my friends on the campus. There were no traffic hazards on the university campus roads as we find it today. There were hardly a few cars on the campus. My regular companions for evening walks were Gurbax Singh of the history department and Omkar Nath Koul of the North Regional Language Centre. This was the time when we used to discuss the campus politics. Dr. Koul used to narrate his love affairs of American university campus and asked me about mine. I have kept a slot for this narrative in Chapter six of this book.

Kirpal Singh Narang, the then VC, was also a regular evening walker. Generally, he was accompanied by his coterie and we avoided his route. Once, he made a prediction that University Professors will be *lakhpati* (owner of one hundred thousand rupees) after retirement as UGC had revised the grades providing dearness allowance (DA) to university teachers with the basic salary of Rs. 400 per month. I wonder why Narang failed to realise that University Professors will be paid one lakh monthly emoluments in the 21st century and be retiring as *crorepatis* (owner of ten million rupees).

After my return from Paris, I was made in-charge of departmental tours. The students' choice was based on my popularity both as a teacher and helper in their personal problems. In 1974, I was asked to conduct a tour of Nepal for ten days. It was during the month of September and due to the late Monsoon rains in Bihar, it was an ordeal to reach the border of Nepal. Our train route beyond Patna was flooded and we had to take a circuitous route to reach Raxaul, a border town in India before entry to Nepal at Birganj. In those days, India-Nepal border was porous and no entry visa was required for Nepal. There was only a customs check post at Birganj. We reached Kathmandu after ten-hour journey by an ordinary private bus and found a lodge at a reasonably low price in the

city centre. We enjoyed our trip to Kathmandu visiting Tribhuvan university, Hindu temples and other monuments in the Himalayan kingdom. My research scholar, Sohan Lal Koul, collected Himalayan rock samples from Kathmandu for fission track dating. We did a lot of shopping as there was no customs duty on goods in Nepal.

Our return journey turned out to be more adventurous. First, we were harassed at the customs check post on the Indian side. There was a collusion between police, customs officials and *tonga-wallas* (horse driven carriage) plying on this route. The *tonga-wallas* knew that we had purchased foreign goods from Kathmandu and asked us to pay handsome amount to take us across the border. In fact, they used to pay a bribe to the police and customs officers on behalf of passengers in their *tonga*. We denied to pay the *tonga-wallahs*, as a result, we were searched by the police party and all our goods were confiscated at the border. Since we had exhausted our money in Kathmandu, we could not pay heavy duty demanded at the customs check post. The rampant corruption by the customs and the police is well known in India and we had a taste of it during this tour.

We reached Patna after a long and tedious journey by train. Our group consisted of young students inclined towards leftist ideology, known as comrades in common parlance. They were not prepared to stay in Takhat Patna Sahib Gurdwara, as it was a religious place. The other option was a lodge or hotel. When they found their pockets empty on reaching Patna, they agreed to have free lodging and boarding facility provided by the Gurdwara management. During this time, an agitation lead by Sarvodaya leader, Jai Parkash Narayan, was going on in Bihar. Our comrades encountered some of his supporters in Patna University and held a debate over the futility of this agitation. We reached Punjabi University campus safe and

sound after this memorable educational tour of Nepal.

My fourteen years service in Punjabi University Patiala was a golden era of my life. I got married in 1966 and was blessed with three sons during my stay on the university campus. I went on to complete my doctorate in High Energy Nuclear Physics in the Marie Curie university of Paris and started my research activity on its campus. My best contribution to medium switchover programme, followed by three awards for my textbooks of Physics in Punjabi, was realised here. Last but not the least, my study of Sikh scripture, Sri Guru Granth Sahib (SGGS), and its scientific interpretation also started at Punjabi University, Patiala.

It will be interesting to recall some episodes of my service period in PU Patiala. During 1967, I was attending a *kirtan* (hymn singing) programme in Gurdwara Singh Sabha, Mall Road, Patiala. Sant Mohan Singh *Brarewallah* (living in Barara, a town in Haryana) was performing *kirtan* with an *iktara* (one wire string instrument), which is very unusual practice in Gurdwaras. He was rendering a long composition from SGGS, known as *Maru Solhe Raaga*, commencing with “*Arbad Narbad Dbudukara*”, which translates to “Billions of years ago there was nothing but utter darkness”. After the recital was over, I met Mohan Singh to know more about this hymn. He advised me to read *Maru Solhe* composition of Guru Nanak in SGGS. On reaching home, I searched and found this long composition in SGGS installed in our home. I was wonderstruck by its poetic beauty and scientific implications about the creation of the Universe. After a few days, I completed my survey of SGGS and prepared my first paper “*Big Bang Cosmology in Science and Sikh Religion*” which was presented during a seminar organised in Punjabi University, Patiala, on the eve of 5th centenary celebrations of Guru Nanak in 1969. In 1975, on the advice and commendation of Vice-Chancellor, Kirpal Singh Narang,

I published my book of essays on Cosmology under the title “*Brahmand di Rachna*”.

Guru Nanak Ashram, Patiala was founded by Giani Narinjan Singh, who was a renowned *kathakar* (exegete) of SGGS. I used to visit this ashram after joining PU Patiala. The morning service usually commenced at 3 AM. I used to get up early and drove ten km. by my two-wheeler to Ashram on the precincts of Patiala city. One day *Giani jee* asked about my routine. I told him that I keep busy with my research scholars till late in the evening. He forbade me to join so early in the morning service and allowed me to come at my own convenience and will. I was made Secretary to conduct the weekly *Satsangs* (congregations) at the ashram. When Jathedar Gurcharan Singh Tohra became the SGPC President for the first time, I was conducting the proceedings to honour Jathedar Tohra. In my welcome speech, I entreated Jathedar Tohra to involve Sikh intellectuals in decision-making programmes of SGPC. The Jathedar replied during his address that Sikh intellectuals have been tried in the past but they have belied their hopes. He cited the case of Gurnam Singh Grewal, ex-CM of Punjab, who left them in the lurch and joined Congress to get the post of Governor. My argument in favour of Sikh intellectuals was ignored by Jathedar Tohra.

When emergency was imposed in India by Indira Gandhi, the Indian Prime Minister in June 1975, I was on a visit to Delhi University concerning my research collaboration. After the emergency, elections were held in 1977. There was resentment against emergency among university academia. During these elections, Jathedar Tohra was fighting the election to Parliament as a candidate of Janta Party against Captain Amarinder Singh, who was a Congress nominee. Since I was against the emergency, so we wanted to support Jathedar Tohra. Prof. Swai Singh, President Sikh Intellectuals Forum of PU

Patiala, wanted to organise this meeting on the university campus but the VC refused to give permission. Swai Singh asked me to act as Secretary and chief coordinator for Tohra's election campaign in the university. We organised the first election rally in village Sheikhpura on the outskirts of the university campus. The teachers were so scared of the attitude of VC that hardly half a dozen joined in our rally. It was a good start considering the support we got from the rural areas. My mother was going from door to door with Mrs. Tohra on the university campus canvassing in support of Jathedar Tohra. On the day of polling, I travelled with Balwant Singh Nihang to the remote villages of Patiala Parliamentary constituency. There was a wave against Congress and in favour of Janta Party everywhere. When the election results were declared, Jathedar Tohra won the election. I made it a point neither to join any victory rally nor seek any political mileage and favour from Tohra. One fact needs to be mentioned in connection with this election. Some of the Sikh Professors of PU Patiala, for example, Balkar Singh, Kehar Singh and Avtar Singh, canvassed in favour of the Congress candidate and against Jathedar Tohra. The members of Sikh Intellectual Forum, who supported Jathedar Tohra openly with men and materials, failed to comprehend this phenomenon.

When I went to France, my step-brothers must have anticipated that I may stay there or move to some other country on a permanent basis after my studies. It was true for most of my colleagues who went for higher studies abroad. They conspired to sell my landed property in my absence. They sold the land owned by my father in village Alipur, near Chhintanwala, and purchased more land elsewhere in Punjab. This conspiracy was revealed by revenue *patwari* of Alipur who was not paid the proposed sum to keep quiet. When the plan was revealed to me on the university campus, I was astonished

how could they deceive me from my inheritance? My mother was really disappointed and started blaming my father who must have acted under the command of my step-mother in this nefarious act of cheating.

The only alternative left with me was to move the court to get justice. I was told by the *patwari* that my share of inherited land was sold by presenting some guy, who impersonated for Hardev Singh Virk, at the time of registration of the sale deed in the revenue court of Nabha, our Tehsil headquarter. I registered a case of cheating against my step-brothers under the section 420 of the Indian Penal Code. The guy who impersonated on my behalf was captured by the police but my brothers got him released on bail. I knew the whole system was corrupted and we lost the case in lower courts. The same thing happened in the sessions court. Ultimately, I went in appeal to High Court Chandigarh and engaged Tehal Singh Mangat to fight my case as a lawyer. Tehal Singh had fought my *Nani's* court cases and knew me very well. He proposed that inheritance cases take too long, it will be appropriate if we patch up and come to a compromise outside the court. Some of my friends and relatives were also involved in this exercise. Prof. Gurpal Singh and Parkash Singh Jammu provided moral support in this hour of trouble. During this whole episode, I lost my faith in human relationships. I entered into a compromise with my father who agreed to pay me Rs. 50,000 in lieu of my share in the inherited property. It caused a lot of heart-burning in our family and we suffered a permanent break in our relationship.

□

Chapter 4

Memories of Guru Nanak Dev University Amritsar

The longest span of my life, running into twenty three years, has been spent in the service of Guru Nanak Dev University (GNDU), Amritsar. I joined as Reader and Head of Physics Department on 10th July 1979 and retired on 30th June 2002 as senior-most Professor in its faculty. The story of my moving to GNDU is interesting and need to be recounted.

After return from Paris in 1972, I met the Vice Chancellor of GNDU, Bishan Singh Samundari, in his office at Khalsa College Amritsar in Jan. 1973. The University campus was under construction and the teaching departments and VC office were operating from the premises of Khalsa College. The VC looked up my face and jokingly said, “The Virks are notorious for the acts of robbery, how could you succeed in getting a doctorate degree in Nuclear Physics from the Marie Curie University of Paris”? I was hardly 31 years old and he considered me too young to head the new Department of Physics. He told me politely that the university is looking for a suitable Professor to head the department.

In 1974, GNDU advertised the post of Professor in Physics. I applied for this post and was called for the interview held in Guru Teg Bahadur Khalsa College, New Delhi. Prof. Rais Ahmed from AMU Aligarh was one of the experts, the other was Prof. FC Aulack from Delhi University. After my interview by the experts, the VC looked up my biodata and asked a teasing question, “How can you reach the topmost rung of the ladder while standing on the lowest”? I understood

the motive of his query. Those days, I was only a Lecturer and wanted to become a Professor, without being a Reader as yet. Hence, I was not a fit candidate for Professorship in the eyes of the VC and got rejected outright. In Jan. 1975, I was selected as a Reader in Punjabi University, Patiala and thus reached the middle rung of the ladder to the Professorship.

My research activity started very well in Punjabi University (PU), Patiala after I was sanctioned two major projects. We had published two dozen papers in Indian and foreign journals. I was sure of competing for Professorship if the post is re-advertised. In the meantime, I learned from reliable sources that the university authorities had contacted some Professor of Physics in a US university to head the Physics department in GNDU. However, the negotiations could not succeed and the post was re-advertised in April 1979. I applied for the post and was called for the interview on June 22 to be held on the GNDU campus. Due to summer vacation in June, I had gone to Hamirpur in Himachal Pradesh to carry on Radon survey under my CSIR project. In my absence, Prof. Sarjit Singh Sandhu, who was Dean Science Faculty in GNDU, visited my house in PU Patiala and told my family that I must appear in the interview of Professorship without fail. I understood the urgency of this message and prepared myself for the interview.

I was not selected for the Professorship at this interview. The new VC, Karam Singh Gill, was determined to start the Physics department. The experts had recommended the name of an IIT Delhi scientist in absentia but VC rejected this proposal as it was not acceptable under the university rules. Prof. Abdus Salam, Nobel Laureate in Physics (1979), was my referee for this post, who had sent a letter of recommendation to the VC for my Professorship in GNDU. I was told by Prof. Sandhu that this letter remained in the files and the VC forgot to present it to the experts. Hence the post of Professor

remained vacant.

After the interview, it was suggested that I should join as Reader and Head. The interview for the post of Reader was to be held on June 30. I was reluctant to appear for the interview but on the persuasion of Prof. Sandhu, I appeared before the expert committee. As was decided earlier, I was selected Reader with three advance increments and a promise to provide a house on the campus. In addition, the VC accepted my demand that one of my Ph.D. students, Surinder Singh Parmar, be appointed as Lecturer to help me in setting up my research laboratory. Reaching PU Patiala, I discussed the prospects of joining as Reader and Head in GNDU. Prof. Kuljit Singh Sidhu of Chemistry in PU advised me to go ahead after getting a leave of absence from PU Patiala.

I met the VC of PU, Amrik Singh, and he sanctioned my leave for three years with immediate effect. He was sure that I shall be promoted as Professor in GNDU, while there was no vacant post of Professor of Physics in PU Patiala. On 10th July, I reported myself on duty in GNDU Amritsar. My joining report was submitted to the deputy registrar, Darshan Singh, in the establishment section. I was impressed by my reception in his office and we became permanent friends. After this formality, I made a courtesy visit to the VC office and demanded that Physics block be vacated for starting the new department. The VC assured me that it will be done as soon as the administrative block gets ready. Till then, we were provided three rooms, one for my office, one for the classroom and the third for the laboratory. He advised me to start the first batch of B.Sc. (Honours) with 15 students. The advertisement for admission was sent in my presence and the admission process was completed by the end of July 1979. Most of our students were from local colleges as we sent our advertisement when admissions had been completed already.

Before my joining GNDU, Physics department was operating from the precincts of Chemistry Block. I met my colleagues Surjit Singh Bhatti and Naresh Kumar Sood and the office clerk, Mr. Sharma. Soon I discovered that the clerk was a chain smoker and my first quarrel took place to stop him. One day, he came to my office and boasted that he is an experienced hand and can train me in running the affairs of the department. I was cut to the quick and turned him out. The first lesson learned by me was that to run the department effectively there was a dire need for efficient support staff. Physics department started with five teachers which served our purpose during the initial stage. Mr. Vivian Haque was our Laboratory supervisor and a very disciplined person, who had retired from the Airforce before joining GNDU.

Punjab has been divided into three geographical regions; Majha, Doaba and Malwa, on the basis of socio-cultural differences. I had lived most of my life in the Malwa belt. In comparison with Malwa, Majha residents had been under the British rule, hence more educated and worldly wise. I had the first-hand experience of this trait after joining GNDU. The day I joined the university, I met Serjinder Singh, a Lecturer in the Chemistry department, who invited me for lunch at his residence. I accepted it willingly as he looked like a perfect Sikh gentleman. On the dining table, he started asking about facilities provided to me in GNDU. I revealed all as a simpleton, without having any doubt about his intentions, that I have been provided accommodation on the campus as a part of my deal with the university and a special privilege for the head of Physics department. I never knew that he is Secretary of GNDU Teachers Association (GNDUTA). The next day, he met the Members of GNDUTA and went on strike against the VC allotting me campus accommodation out of the turn. After two days sit-in strike, my privilege was withdrawn by the VC.

Rajinder Singh Sandhu, the Dean Academics of GNDU, made enquiries from me to know to whom I had leaked the facility of campus accommodation. I told him all about my meeting with Secretary GNDUTA. He warned me that I shall lose my privilege to stay on the campus. Ultimately, my privilege was restored by the university Syndicate but my family had to stay in one room accommodation in the University Guest House for three months due to my folly of speaking to Serjinder Singh. This was another lesson of my life that appearances look deceptive and one should not rely upon strangers without testing their fidelity.

While I was waiting for my promotion to Professorship in GNDU, Punjab Agriculture University (PAU) advertised a post of Professor of Physics. I was called for the interview in July 1980 and got selected. My earlier training in Biophysics stood me in good stead as the Chairman of the selection committee, Dr. Amarjit Singh, Director of CEERI Pilani, asked me questions about the relative sizes of genes and chromosomes. The Dean of Basic Sciences of PAU called me to his office and asked for my frank opinion about joining. I told him that my first choice will be GNDU and shall wait for my chance till December end. The selection letter of PAU served my purpose. The VC GNDU had to advertise the post of Professor and interview was arranged in December 1980. There were sixteen candidates and six were already Professors who wanted to join GNDU. The opinion of experts was in my favour. I was asked questions about Grand Unification Theories (GUT) which was my favourite subject. Registrar issued my letter of appointment after the Syndicate meeting held next day after the interview and I joined as Professor of Physics in GNDU Amritsar. My desire and aim to create a department of Physics in GNDU was finally going to be fulfilled.

I met Prof. PS Gill, my mentor in AMU Aligarh, who was Director in CSIO Chandigarh, to share this good news. He

was pleased to hear this news. After a pause, he recalled that from Kashmir to Kalyani University in West Bengal, all heads of Physics departments were his old students from AMU. He advised me to recruit teachers on merit and avoid local appointments from within Punjab only. I followed his advice strictly. We recruited PK Chattopadhyay and Amitabh Sinha, two Bengali scientists to teach Theoretical Physics. From 1979 to 1983, our faculty strength grew from five to eight. There was a good balance between Theory and Experimental teaching. However, this equilibrium was disturbed after Blue Star operation in Punjab. The faculty recruited from other states was feeling unsafe and started moving from GNDU to other safer locations. My efforts to invite qualified teachers from research centres like TIFR Bombay proved to be unsuccessful.

The events like Blue Star Operation in Punjab affected the functioning of GNDU as the university was close to the epicentre of terrorism. Our university students were involved both directly and indirectly. The ringleaders did not allow the normal functioning of GNDU and copying during university examinations became a rule rather than the exception. I was not scared of ruffians but our administration gave them long ropes. The university reputation took a hit. Some organisations wrote clearly banning the entry of our university products in admissions and jobs. Our research activity also suffered as no one was interested from other universities to join research and the supply firms were reluctant in supplying the equipment. When I was Dean Academics, there happened two shooting incidents on the campus. I had to face the music as the VC went on long leave fearing some strikes on the campus. Once in his absence, students attacked my office but I was protected by the security forces on the campus. This incident was reported in the White Paper of the *Shiromani Gurdwara Parbandhak Committee* (SGPC) authored by Gurdarshan Singh Dhillon, a Sikh scholar and historian.

During the years of my service in GNDU, I was invited to many international conferences and Summer Schools to present our research. In 1981, a Summer School was organised at Nathia Gali, 80 km. from Islamabad in Pakistan. This annual Summer School programme was funded by ICTP, Trieste (Italy) under the direction of Prof. Abdus Salam. I attended one such School in June 1981. This was my first trip to Pakistan after the partition of India in 1947. I crossed the Wagah border on foot and was scared of entering Pakistan. It was my official visit and I was allowed entry visa without any fuss. No one came to pick me up at the border, so I had to travel by a rickety bus to Lahore.

On reaching Lahore, I called my friend Jean Marie Lafont, who was teaching French in Punjab University, Lahore those days. He picked me up from the bus stop and I spent my first night in Pakistan in his home. Early the next morning, I boarded a minibus for Rawalpindi and reported myself in the police station, as I was advised to do. I was provided all help and dispatched to Nathia Gali in a Jeep. Our route was passing through Murree, the most important hill station in Pakistan created by the British. In the evening, I reached Nathia Gali, a beautiful hill station and was lodged in an independent single room at my disposal.

During the Summer School, I was introduced to Nobel Laureate, Samuel C.C. Ting from the USA, who delivered us lectures on Particle Physics. We made a trip to Peshawar passing through historical towns of Abbottabad, Haripur and Hassan Abdal. We reached Peshawar after a brief stopover at the Indus river. On the return journey, I was allowed to visit the Panja Sahib Gurdwara in the memory of Guru Nanak. I paid obeisance, took photos of the imprint of Guru Nanak's hand etched in the stone slab and returned to Nathia Gali. On the parting day, a farewell was organised by the Director, Pakistan

Atomic Energy Commission. I was his favourite guest at the dinner party. On his bidding, I had to perform at the *tappa* (folk couplets) singing competition with a famous *Pashto* singer from Peshawar.

After three weeks, I returned to Islamabad and stayed for the night in PINSTECH Guest House. All foreign participants were allowed to visit PINSTECH except me, as being an Indian, I was denied permission. I think it is reciprocal, we Indians do not allow the Pakistani counterparts to visit our Atomic Energy Establishment at BARC, Trombay. On the return journey to Lahore, I asked the driver to drop me at Kamoke, my place of residence before partition. I had a vague idea of the location of my house. The locals guided me to my house and the old memories flooded my mind with emotions. The Muslims living in my house were friendly, who had migrated from Fatehgarh Churian town of Amritsar district. A crowd assembled in the street to see a Sikh visitor. On reaching Lahore, I called my friend Asgar Ali of Paris days, who took care of my stay for two nights at his residence located in the famous township of Gulberg in Lahore. I was provided a chauffeur driven car for my visit to Nankana Sahib. I returned to GNDU Amritsar after a memorable visit to Pakistan.

I had the privilege of visiting the International Centre for Theoretical Physics (ICTP), Trieste, Italy for nearly a dozen times in the capacity of a Senior Associate. From ICTP, I used to visit research laboratories all over Europe to learn new techniques of experimental physics. I have recorded an account of these visits in my travelogue, "*Europe Da Safarnama*". Some of these visits were funded under the South-South Fellowship programme of Third World Academy of Sciences (TWAS). I visited China, Iran and Malaysia under TWAS fellowship. I started writing my travelogues in 1980 after joining GNDU and got wide publicity through vernacular newspapers and

magazines. The first article about my visit to Yugoslavia was published in *Qaumi Ekta*, edited by Rajinder Singh of Delhi.

When I was Dean Science Faculty in GNDU, I tried to introduce some reforms in both teaching and research. There was some opposition from heads of Science departments. I made it compulsory to publish one paper before registration for Ph.D. degree and two research papers before submission of the Ph.D. thesis. After twenty years, UGC has implemented this reform in the Indian universities. This has definitely improved the quality of research.

When I was installed as Dean Academics of GNDU, I tried to normalise the distribution of Ph.D. candidates among faculty members. The practice in vogue was that Professor and Head of the department got the lion's share and lecturers got almost nothing. I introduced the norm of two candidates for a Lecturer, four for a Reader and six for a Professor. To set an example, I myself never supervised more than six Ph.D. candidates. I learn the Indian universities do not follow this norm now, in view of a rat race for obtaining Ph.D. by hook or by crook, and Professors supervise dozens of Ph.D. candidates. Just imagine how much time they devote to guiding their research scholars. Most of the research scholars follow the cut and paste technique to write their thesis. Dr. Jai Rup Singh, during his tenure of Vice-Chancellorship in GNDU, suspended two teachers because they copied data from others theses to prepare their own.

Perhaps, I was the first university teacher and researcher in PU Patiala to start inter-disciplinary research in 1973. I wanted to carry this tradition in GNDU Amritsar. In research, I had full liberty to work in interdisciplinary areas of Geophysics, Geochemistry, Seismology, History and Philosophy of Science, Sikh Religion and even Punjabi Literature. I delivered my first lecture, "Punjabi Poetry: A study

in Interactions”, in the School of Punjabi Studies at GNDU. It was a new approach and appreciated by Punjabi scholars. I started my series of lectures for students of English literature, Political science, and Biology. However, Jagtar Singh Grewal, the then VC, was not pleased with my interdisciplinary interactions. He called me to his office and advised me politely to remain confined to my own discipline, rather than indulging in activities of other disciplines. I did not relish his advice. I feel his advice was against the spirit of UGC guidelines.

Operation Blue Star happened during my service in GNDU. In fact, its seeds were sown a year before my joining at GNDU. The Sikh-Nirankari clash took place in April 1978 which led to the massacre of 13 Sikhs. Amritsar was the epicentre of Sikh *Morcha*s (agitations) since 1981. The peaceful life in the city and the university campus was affected. I was not directly involved in these *Morcha*s but emotionally attached with the Punjab and Sikh situation. My book “*Sikh Qaum da Dard ate Santap* (The Agony and Misfortune of the Sikh Nation)” is based on my essays written during this period. My main concern was to keep my research activity going on despite threats to my life when I was Dean Academics of GNDU.

It was a big surprise when I received a letter dated 10th April 1985 from Bhan Singh, Secretary SGPC, asking me to attend a function at Gurdwara Manji Sahib, within the Golden Temple complex, for receiving a ‘robe of honour’ on the occasion of Vaisakhi on 13th April. I was informed that only a few Sikhs who had made sacrifices for the Sikh Panth were included in this list. The other invitees for this special honour included Khushwant Singh, Captain Amarinder Singh (now Punjab CM) and Bhagat Puran Singh of Pingalwara fame. I reached the venue at 10 AM and occupied a place in the last rows of Manji Sahib Diwan Hall. As soon as the organisers called Bhagat Puran Singh to receive the *Siropa* ‘the robe of

honour', there was *balla-gulla* (commotion) created by the so-called *Khalistanis* present in the congregation against these awards. Their objection was why the families of killed martyrs, like Beant Singh and Satwant Singh, had not been invited at this function. I keep this letter as a trophy and published it in my autobiography "*Mera Jeevan Safar*" in Punjabi.

The GNDU Amritsar campus is spread over 500 acres of land which was acquired from Khalsa College located in its vicinity. The built-up area was less than 30% and the remaining 70% was under cultivation. When I joined GNDU, the VC asked me to look after the agriculture farm in addition to my teaching duties. There was no remuneration for this job. I enjoyed my extra-curricular activity for three years and introduced some reforms to improve the income of the university farm. Another duty assigned to me, which was not to my liking, was to act as enquiry officer in embezzlement cases of the university. Most of these pertained to Executive Engineer's office. As a result, I annoyed the officers of Construction Wing and lost their sympathy when I needed their help in repair work at my own house on the campus.

French language teaching was started in GNDU during 1981. The students of the English department were interested to pursue this course. I had learned French during my stay in France and wrote my doctoral dissertation and some research papers in French. On return from Paris, I had taught French in Punjabi University Patiala. I accepted this assignment willingly on the basis of some extra remuneration. When I wrote to the VC to provide office staff, he was annoyed with my petty demand. In protest, I left this assignment after a year. Later on, a regular teacher of the French language was employed by the university.

The growth of Physics department was to my entire satisfaction despite several handicaps and prevailing conditions

of uncertainty due to acts of terrorism in Amritsar. I started with five teachers in 1979 but before I left the headship, the faculty strength grew to 22. During 1986, rotation of headship was introduced in GNDU. As a consequence, Professor had to work under his junior Reader or Lecturer. This led to a lot of bickering in teaching departments. I was not reconciled to this rotation of headship. I believe this is a typical Indian device where Professor's status is compromised with his juniors. In the USA, Professors deserve a most respectful status both in academia and society. The professor is independent in making decisions concerning his teaching and research but it is not so in India.

My research contributions and collaborations continued to thrive despite the change of headship. Our research group got recognition globally in the area of Radon studies and applications to earthquake prediction and environmental health hazards. I was not a trained Seismologist and depended upon the help provided by my friends and collaborators. An incident needs to be narrated how providence helped us. I was visiting Marianne Hook, UNESCO office librarian in Jor Bagh, Delhi. It was a mere coincidence that she was busy in shifting the library to its new building and asked me to have a look on the redundant stuff going to be dumped as trash. When I started my search, I glanced a title of the book which was on Earthquakes. I lifted it and brought to my laboratory in GNDU. I discovered that it was a proceedings volume of a UNESCO Conference held on the prediction of earthquakes in Paris. Most of my research scholars used this volume to carry out their investigations and writing their papers.

The city of Golden Temple provided a source of spiritual solace for my family. It was not as crowded during the eighties as it looks today. When Reimer Spohr or some other scientist visited my laboratory, it was my routine duty to escort him to

the Golden Temple. Once our guest reported that the *kirtan* (hymn singing) going on inside the holy precincts induces him to sleep. I had already experienced this state of ecstatic joy and confirmed his finding. In fact, a focussed mind inside the Golden Temple goes into the state of relaxation which induces one to sleep.

We celebrated the marriages of our three sons in our spacious residence on GNDU campus. Mrs. Virk was fond of gardening as her hobby and our house was always in full blossom, an envy for our neighbours. My mother had been living with us since I got married. She used to accompany me on my pilgrimage to historic Gurdwaras in Punjab and Himachal Pradesh. Once, I was on examination duty at MD University, Rohtak where she suffered a heart attack. Fortunately, we were staying in PGI Rohtak guest house where immediate medical help was provided. The doctor advised her complete rest. He confided that heart had suffered damage and she will survive two to three years. In 1992, she died in her sleep due to cardiac arrest. I was sleeping in another room and came to know that she had died only the next morning. I was repentant for many days why I failed in my duty as a son to give her solace on the last journey of her life.

□

Chapter 5

My Travels Around the Globe: A Synoptic View

My curiosity to explore the world is a God's gift. Since my childhood, I enjoyed travelling but the mode of travel had been changing continuously. As a child, I was accompanied by my *Nani* (maternal grandma) to meet relatives living in Punjab. Those days most short journeys were covered on foot as there were no metalled roads and means of transport were primitive. I remember attending the marriage of my class fellow who was hardly eleven years old and the journey to the village of his in-laws was performed by bullock-cart. Sometimes, I used *tonga* as a faster mode of travel from my village Chhokran to Malerkotla. The first journey by Omnibus was made by me in 1951 on a *kacha* (dirt) road from Lassoï to Khanna. When the bus got stuck up on a dusty or muddy spot, passengers were asked to get down to pull it out. In school and college days, I used to travel riding my import quality BSA bicycle. I covered long distances from 50-100 km. on my bicycle to visit distant relatives and friends. This mode of travel was popular during my days of youth.

The first breakthrough in my journeys around the globe came during my service in the Punjabi University, Patiala. The first opportunity was provided by my foreign trip by Air France to Paris in 1970 for higher studies. The second chance was provided by ICTP, Trieste for attending a ten weeks Workshop on Physics of Earth. Later on, as Senior Associate of ICTP, I had the privilege to visit half a dozen developing countries. But most of my trips abroad were planned due to my participation in international conferences during my service

days at GNDU Amritsar. Before retirement, I have journeyed to nearly fifty countries of Europe, Asia, the Americas (North & South), Australia and Africa. I travelled to Europe more than a dozen times, visiting all countries from Portugal to Sweden and down to Turkey and Russia by train using Euro-Rail pass. My travelogues had been published in three volumes: “*Meri Vishav Yatra* (My Journey around the Globe)”, “*Europe Da Safarnama* (Travelogue of Europe)” and “*Amrika - Canada Di Yatra* (Journey to the USA and Canada)” by Tarlochan Publishers, Chandigarh. A synoptic view of my journey around the globe will be presented here.

My journeys to Hungary: I made several trips to Budapest and Debrecen in Hungary. During my second trip to ICTP, Trieste, I made a plan to visit Atomic Physics Laboratory in Debrecen in 1981. I was invited by G. Somogyi, a researcher in Nuclear Track Studies and their Applications. My trip was funded by ICTP. I landed at Budapest airport and got a visitor visa at the airport. I was delayed at the airport and had to rush by taxi to Budapest-Nyugati-Pu railway station to catch my train to Debrecen. Despite language problem, the driver brought me to the proper station, otherwise, I was not aware that there were three railway stations in Budapest. I was looking for a seat in the last coach of the train when an old couple offered me a place by squeezing themselves.

To make me feel comfortable, the couple enquired about my purpose of visit to Debrecen. They could hardly converse in English and my Russian was not up to the mark to reply to their query. In the meantime, another younger couple sitting in the front row came to our help. They were fluent in English. The lady, Kish Borbala, was an English teacher and her husband Josef was a scientist, who was working in the same institute where I was going. Josef knew my host Somogyi and about my visit. After two hours of travel, we reached Debrecen railway

station. I started looking around for my host Somogyi on the platform but he was waiting for me outside the railway station. Seeing my predicament, Kish Borbala suggested that I should accompany them to Nyiregyhaza, the next railway station, and spend one night in their home. I was not confident to find my host during late evening hours and to avoid any risk in a strange country, I accepted the proposal of Kish Borbala to be their guest.

On reaching Nyiregyhaza, a city on the border of Ukraine, Kish asked for my choice of food. Being a vegetarian, it was a problem to find some dishes readymade from some local restaurant. Kish brought an English dictionary so that I could make a choice of my food. She cooked whatever was available at home and we had late dinner that night. Next morning, I returned to Debrecen with Josef to meet my host. I was surprised to know that Somogyi had already known about my departure to Nyiregyhaza last night. How could it be possible? I was making a guess when Somogyi told me that the old couple sitting in my coach had informed him about my movement to Nyiregyhaza, after looking up for his telephone from the directory. How friendly are Hungarians? I discovered after this episode.

I was allotted accommodation in the guest house of the institute where I could cook Indian food. I met scientists working in the institute and made acquaintance with Ilona Hunyadi, who was a senior scientist interested in Radon studies. I was invited to her house to taste Hungarian food. Our friendship turned into a family relationship and I used to call Ilona my sister. After one week, I returned to Budapest and stayed for one night to visit this city. I found Budapest one of the most beautiful cities in Europe. It is divided into three zones, Buda, Obuda and Pest. The river Danube separates Buda and Pest which are connected through a series of old

bridges. I made a tour of historic monuments on the Buda side. I returned to ICTP Trieste by the train passing through Belgrade on the way.

In December 1990, I organised an International Conference on Rare Gas Geochemistry in GNDU Amritsar. There were three participants from Hungary: Ilona Hunyadi, Ester Toth, and George Marx. George was a senior Professor in the *Eötvös* Loránd University of Budapest. He invited me to write a joint proposal for Radon studies under Indo-Hungarian Exchange programme of Department of Science and Technology (DST), Govt. of India. Our research collaboration continued for five years (1995-2000) and I visited Hungary almost every year. The stipend under this exchange programme was the bare minimum and I had to stay in a family without paying any rent. George Marx arranged my stay in his research scholar's house located in Moscow square of Budapest. I enjoyed the hospitality of Eva Papp, mother of the research student, who treated me extremely well. Eva visited India in 2002 on the occasion of farewell organised on the eve of my retirement from GNDU.

My most memorable visits in Hungary were to a gypsy village Matradrescke, situated among the Matra hills. Ester Toth, a friend of George and my collaborator had her house in this village. She devoted her life to the study of cancer in rural population caused by Radon and Carbon dioxide emanating from the sub-soil underneath the houses. A similar study was undertaken by our research group on my return to GNDU in the Malwa belt of Punjab which was prone to cancer risk. In 2005, I learned from Ester Toth that George Marx had died of cancer just after retirement.

Budapest was like my second home in Hungary. I had made friendly visits to Gyor, Eger, and Pannonhalma. The Benedictine Archabbey of Pannonhalma is the oldest

monastery in Hungary founded in 996 AD. Another big attraction was Krishna valley located in Somogyvámos village of Hungary. There is a Hare Rama Hare Krishna sect temple with pure vegetarian food service, organic farm and a beautiful garden. The modern implements, like tractors and farm machines, are not used but only bullocks yoked to plough for growing food. Use of electricity is also avoided in the valley. It is one of the famous ISKCON spiritual centres of A.C. Bhaktivedanta Swami Prabhupada in a remote village of Hungary.

My trip to China: I was member International Nuclear Track Society (INTS) which is responsible for organising International Conferences on Nuclear Tracks in Solids. The 16th Conference in this series was being organised in Beijing, China in September 1992. Our group had sent five research papers for presentation at this conference. I was expecting an invitation but was not sure of getting return airfare from the organisers. As luck would have it, I was awarded a Travelling Fellowship under TWAS (Third World Academy of Sciences) for my four weeks visit to China. I wrote a letter to Prof. Shu-Lin-Guo, who was organiser of the International conference, to send me an invitation letter from China Atomic Energy Authority (CAEA), Beijing for permission to visit and work in it. I was not sure that permission will be granted as the relations between India and China were far from cordial. However, it was a big surprise that I got permission to work in Prof. Guo's laboratory under TWAS fellowship.

I travelled via Hong Kong and reached Beijing International airport before noon of September 2, 1992. My host Prof. Guo received me at the airport. I was treated as a VIP guest and allowed to get out of the customs and immigration checkpoints without any botheration. I was transported in a chauffeur-driven car of CAEA to Minzu Hotel

in the Beijing city. I observed the roads were clean and wide but hardly any cars running. This was the time when China had opted for reforms in its economy and was trying to wriggle out of the Maoist era legacy. Most of the workers were still wearing Mao suits (Chinese tunic suit) and riding on bicycles as the only means of transportation.

I was told by my host that once Indian Prime Minister, Pundit Nehru, had stayed in the Minzu hotel when India-China were *bhai-bhai* (brother-brother). This slogan got the hit for the worst after China-India war of 1962. The 3-star hotel was my residence for the duration of the conference and after that, I was shifted to CAEA guest house 50 km. outside the Beijing city. Before the conference started, I was feeling bored and made a tour of Beijing city without the help of a local guide. My first trip was made to Tiananmen Square where university students protested against the communist regime in 1989 and got killed under the rolling wheels of military tanks. By chance, a student spotted me inside a museum established in commemoration of the Chinese Cultural Revolution. He wanted to narrate the story of the massacre of students in the Tiananmen Square but I avoided him fearing the repercussions of my dialogue.

I presented our papers and met delegates from over twenty five countries. It was to my surprise that delegates from the USA and Europe were getting special treatment in the matter of tourist facilities. China wanted to open its gates to developed countries and was seeking research collaborations, hence this attitude. All the delegates were invited to an evening dinner and dance programme after our trip to the Great Wall of China. This great monument was built by the rulers of the Ming Dynasty during the 14th century. After the conference, I visited the Forbidden City in central Beijing, which served as a palace to 24 emperors during the Ming and Qing Dynasties (1368 -

1911). It has been now converted to a museum spread over one hundred acres and is a mirror to Chinese history and culture.

My stay in the CAEA guest house was made comfortable. I was served vegetarian food to my liking though most of the Chinese eat meat. I was told by friends that Chinese relish snake meat as well as dog meat. It is a proverbial saying that Chinese can eat anything from a flying bird to something crawling on the earth. My movement was restricted from the guest house to the CAEA laboratory. I could visit the Nuclear Reactors area with special permission of the director. The buildings of CAEA were of simple design and not pompous. The residential accommodation at CAEA was limited to two bedrooms only; it was allotted on the size of the family and not on the status of the employee. One child per family norm was in force in China. There were no private baths in homes and all had to use community baths. Medical facilities and education were free and at par for all sections of the society. I could see the levelling of the social structure under the communist regime.

Before my return, I planned a visit to the Institute of Geophysics and met its deputy director, Madam Yang Yurong, whom I knew having met her in ICTP Trieste, Italy in a Summer School. She proposed that I should visit Tangshan which was destroyed by an earthquake of magnitude 7.8 on the Richter scale in 1976, killing nearly five hundred thousand persons. The new Tangshan is a flourishing city constructed on the ruins of the old city but one can observe the remnants of the quake site kept intact near the monument raised in the memory of the dead. On the return journey, I found small tractors and horse driven carts being used in the Chinese rural areas.

China of 1992 was still a developing country. I was impressed by its school system of providing equal opportunity in education. There was no unemployment and work was

provided to all irrespective of educational qualifications. The salary differential was kept to the minimum. There were no strikes in the factories due to the rigid discipline imposed by the communist regime. The present boom in the Chinese economy is a recent phenomenon. I wonder during the last twenty five years China had made so much progress in Science and Technology that it is challenging all super-powers, including the USA. It is running highest speed trains in the world, at the speed of 500 km. per hour, between Beijing and Shanghai.

My Circuit of Singapore-Malaysia-Thailand: On return from Beijing, I had a stopover at Bangkok in Thailand for five days. I was invited to participate in an International Conference on Earthquakes being organised by the Asian Institute of Technology (AIT) in Khlong Luang, 40 km. outside Bangkok. AIT had been created under Southeast Asia Treaty Organization (SEATO), a multinational organisation set up to counter communist influence in southeast Asia. I enjoyed AIT hospitality and met some local Indian students. I learned Indians are doing a flourishing business in Thailand and Sikhs constitute an influential group. They settled here before the partition of India. *Namdhari* (a sect of Sikhism) Tarlok Singh was very popular among Thais and he had direct access to King Bhumibol of Thailand. By chance, I met the grandson of Tarlok Singh studying in AIT, who narrated the story of his family.

I made a half-day trip to Ayutthaya, a historic town 80 km. from Bangkok on the same route which touched AIT campus. It is named after Ayodhya - the birthplace of Lord Rama in India. In fact, Thai kings called themselves as Rama and their capital Ayodhya (Ayutthaya in Thai), in order to establish their lineage with Indian king Rama. It remained as Capitol of Thailand for four hundred years until it was destroyed

by the Burmese in 1767. I visited the ancient archaeological site that contains palaces, Buddhist temples, monasteries, and statues. Thailand has adopted Buddhism as its state religion. One can see Buddhist temples everywhere in the countryside. The remnants of Ayodhya reminded me of the glory of Buddhism which spread out from India during the rule of Ashoka, the Great, but it was uprooted from India, its place of birth.

The organisers of the conference arranged a tour of the Bangkok city on the last day. We visited the Buddhist temples with gold-plated Buddhas of huge size. The Bangkok city has an Indian market, *Phaburat*, known as Little India. One can purchase any Indian item, starting from textiles to *samosas* and sweets, in this market. If you purchase a woollen suit piece from this market in the evening, the stitched suit will be delivered before your mid-night flight. I stayed for one night in an Indian hotel in *Phaburat*. The next morning, I paid a visit to the local Gurdwara which was also running Khalsa High School from its precincts. I learn the Khalsa school has moved out to its magnificent new building now. The bazaars of Bangkok were as crowded as in India and the mode of transport was also identical, the three-wheeler *tuk-tuk*. Chao Phraya river passes through Bangkok. I enjoyed the boat ride and visited local vegetable and fish markets on its banks. Later in the evening, I watched huge crowds participating in the birthday celebrations of King Bhumibol.

My trip to Kuala Lumpur, capital of Malaysia, was organised under the patronage of TWAS in December 1991. I was invited by Rosli Mahat, a young researcher from the Physics department in the University of Malaya in Kuala Lumpur for collaboration in Radon studies project. My stay was arranged in the university guest house. I never knew the month of December will be as hot and humid as July-August in Punjab.

Being near the equator, it was just opposite to the weather in Punjab. Luckily, I found many Sikh students on the university campus. During the British rule, Malaysia had a great attraction for Punjabi immigrants. The police force and army were dominated by the Punjabi officers before its freedom on 31 August 1957.

I made friends with a young Malaysian Sikh student who offered me conveyance facility on his motorcycle. On weekends, we used to make a tour of city parks, Gurdwaras, and other monuments. Kuala Lumpur is dominated by Muslims as a whole but Chinese and Indians are controlling the big business houses despite restrictions of all types. The Sikh population was less than ten percent in the city but there were 13 Gurdwaras, in comparison with 12 mosques, a symbol of Sikh prosperity in Kuala Lumpur. Avtar Singh, President of the Sikh Naujawan Sabha Malaysia, invited me for a lecture. I met Doctor Harbans Kaur Virk, a famous gynaecologist, who invited me for dinner. This family had given asylum to Subhas Chandra Bose before his escape from Malaysia.

Before my return from Malaysia, I made a trip to beautiful Penang city located on an island connected by a bridge to the mainland. The city of Penang has many popular spots for tourists, including Cornwallis fort, an old port in George town and botanic gardens. Ipoh city is another colonial landmark in Malaysia. I made a stopover in this city to join a celebration in its Gurdwara. Its rapid growth was attributed to silver and tin mining in its neighbourhood. In addition to the Sikh population of Punjab, the Tamils are doing roaring business in all cities of Malaysia.

My return journey to India was booked via Singapore. Before 1957, Singapore was part of Malaya under the British rule. After independence, it is now a sovereign city-state and island country dominated by the Chinese population. My stay

was arranged in Central Sikh Gurdwara for two nights. My host, Bhajan Singh, took me around the city. There were four Gurdwaras and new year eve was celebrated by holding *kirtan* (hymn singing) till midnight. The Sentosa island is the world-famous recreation spot in Singapore. Singapore is a flourishing world economy and high tech state.

I was impressed by the activities of Gurdwara management which is running Punjabi evening classes on regular basis in Central Sikh Gurdwara. Punjabi was allowed to be taught as a third language in high schools of Singapore but the Sikh community had to financially support this programme. My lecture was arranged for Punjabi class as well as in Central Sikh Gurdwara for the congregation. I met President of the Sikh Society, Chuhar Singh Sidhu, who rose to be the Chief Justice of Singapore Supreme Court. My wish to visit the monument raised in the memory of Indian freedom fighter, Bhai Maharaj Singh, in Singapore was not fulfilled. I took the Air India flight from Singapore Changi Airport to New Delhi on 1st Jan. 1992.

□

Chapter 6

The Role of Women in My Life

The role of women in my life has been of paramount importance. Professor Puran Singh paid the highest tribute to the woman in one of his essays “Bread, Woman and the Bridegroom” in the book “The Spirit Born People”: “Woman shall be the second best God or God of the intellectual on earth”. In my life, I saw the woman not as the second best God but as the first best God in the image of My Mother. She not only gave me birth but also kept me tuned to the celestial realms of Sikh spirituality. People ask me why I love *Sikhi*? I tell them it is in my genetic code. My mother did so much recitation of *Gurbani* (utterances of the Gurus) when I was in her womb, that it changed my genetic code. If transmutations are possible in radioactive substances in nature and can be induced artificially in a research laboratory where I worked in the Marie Curie University of Paris, then why not at the biological level in a foetus?

The other woman in my family whom I adored as a role model was my *bhua jee* (my father’s sister). She made immense sacrifices to bring up the family after her marriage broke up. She was supportive in my endeavours of getting higher education when my father was having second thoughts. I had no real sister or daughter in my family, as a consequence, I missed the experience of their intimate love. However, the village belles treated me with sisterly love and treated me as an innocent boy who deserved their affection. The other boys of my age used to tease the girls for fun but I did not dare to adopt their technique due to my shy nature. I remained attached

to my mother for most of my life and acquired feminine traits in my character.

During my school days, co-education was a rare phenomenon. In lower-middle classes, a young girl from village Siarh took admission in our school at Bhurthala Mander. I was fascinated by her at the age of eleven but could not dare to talk to her in the class. After she left the school, I chanced to meet her in village Lasso in the house of a relative but avoided to express my love or friendship. This was the first occasion when a spark of love was lit up in my heart. I believe the feeling of love sprouts in every heart even at a much younger age. That is why childhood friendships last so long.

After my middle school examination, I travelled by train with my *Nani* (maternal grandma) from Malerkotla to Amritsar during summer vacation to have a dip in the holy *sarovar* (pond) of the Golden Temple. It was a journey by night train and there were no sleeper berths in the third class bogie. A military Colonel was travelling with his family in the same bogie from Ambala to Amritsar. The Colonel was feeling restless and complaining to his wife that why he opted to travel by third class when he deserved to travel by the first class railway coach. The family was travelling with a young beautiful girl of my age. In the poorly lit bogie, I stealthily glanced at her face. It was love at the first sight. I kept awake the whole night and reached Amritsar early morning without exchanging a word with her. Before returning to Malerkotla by train, I entreated with my *Nani* to get my turban dyed in pink. She was a bit surprised by my insistence and this silly demand. I did not want to reveal my mind to *Nani* but started day-dreaming that if perchance I meet her again in the train, I should look attractive. This was the second time in my school days when I was stung by the love waves.

In College days, I had to face the hard realities of my life.

It was like a survival of the fittest. I had no time and tendency to indulge in love affairs. Some of my classmates were running after the girls. Most of the girls in my class used to travel by train from Dhuri and Ahmedgarh to reach our college in Malerkotla. A group of naughty boys used to meet them at the railway station and follow their *tongas* right up to the college gate. A beautiful Muslim girl of Malerkotla was studying in my senior class. She was always clad in a *burqa* (worn by Muslim women) but her love affairs with a rich *Nawabzada* became the talk of the town.

In Mohindra College Patiala, I started living in the hostel. We had eight girls doing B.Sc. in my class. I had rarely spoken with any girl during my two years of stay. Our class fellow, Zoravar Singh Dhaliwal, used to tell tales of his love affairs to amuse us. Our seniors were notorious for indulging in games of love. Warden's quarter was just outside the boundary of our hostel. Once our senior invited his girlfriend, who happened to be Warden's sister, to his hostel room by dressing her in men's wear as a camouflage. Such secret love affairs get exposed or revealed intentionally to gain popularity.

In Aligarh Muslim University (AMU), Aligarh, we had only two girls in our M.Sc. class. Ratna Koul was a Kashmiri pundit girl from Srinagar and Suraya Khatoon was a Muslim girl belonging to a well-to-do family of Aligarh. She was coming to our class without wearing a *burqa*, which was obligatory for girls in the Muslim families. Some Muslim boys in my class wanted to make friendship with Suraya but she was not giving them lift. However, our most favourite young teacher, Sharif Ahmad, was involved in a one-sided love affair with Suraya, which made her jittery. The most famous love affair in the history of AMU was between Rais Ahmad of Physics department and Shakti Rani of the Chemistry department. It lead to some trouble in the city and Rais Ahmad had to leave

Aligarh to avoid public wrath. Prof. PS Gill, head of Physics department in AMU, was not in favour of this inter-religious marriage and he advised Rais Ahmad to join Kashmir university at Srinagar.

My Love Affairs in Paris: I was married with two sons when I joined the Marie Curie University of Paris in 1970 for my doctoral studies in Nuclear Physics. A Kashmiri boy in the Indian hostel warned me to be on my guard as turbaned Sikhs were a great attraction in Paris university. He was right to some extent, I started getting wide publicity in the media advertisements for Air India and other companies. I could not afford to indulge in love affairs as my research investigations kept me busy all day long for 10-12 hours on weekdays. The only pastime was afforded by week-end excursions to Chateaux (castles) and other historical monuments in France.

Felicia Gobdanowski of Chile: My first excursion was to Rouen, a city made famous by Joan of Arc, who was burnt alive at the stake as a young girl of nineteen. It was a cold day and I was amused to visit this holy city and the Cathedral consecrated to her memory. Latin American students were in the majority in this excursion. Felicia Gobdanowski from Chile could speak English and started a dialogue to know about my religion. I could judge from her queries that she wanted my friendship. In her introduction, she told me that her father was a Roman Catholic priest who migrated from Poland to Chile after the Second World War to escape Russian persecution. Her sister was already married to a French and settled in Paris. She had come to study French literature at Sorbonne university. Felicia had read Gitanjali by Rabindranath Tagore and was interested to know more about Indian culture.

During our second excursion to Chateaux of Loire valley, Felicia met me again and started some lively discussion about India. She wanted to know more about my personal life and

plans to study and stay in Paris. I told her frankly that my plan is to get my doctorate degree and return to India to join my family. Perhaps, she was looking for a life partner who could marry and stay with her in Paris as her sister had done earlier. Felicia arranged a dinner party at her apartment where she had invited her sister and other friends from Latin America. I was a special invitee and introduced to all her friends. This was my first late night party in Paris and I sent photos to my wife in India. During my stay in Paris, I had to write about my life-style and other events to my better-half every week. It is my belief that husband-wife relationship must rest on pillars of mutual faith and understanding.

I remained busy with my research activities and did not meet Felicia for two months. One day after finishing my work in the laboratory, I proceeded to my residence but on the way, I thought of calling upon Felicia. It was late evening when I knocked at her door. She refused to open the door and advised me never to visit a single woman at late hours. She was right, I failed to call her before my arrival. In a dejected mood, I climbed down by the lift. When I reached on the road, Felicia called me from her apartment window to express her regrets. I knew she will be joining the excursion to a castle on the outskirts of Paris next day. I found Felicia walking in the castle with a guy from Bolivia. She did not show keenness to talk to me. I started guessing that last night's episode must have disturbed her mind. I was wrong. In fact, Felicia was looking for a life partner and she found out, I am not an eligible bachelor. Our meetings became rarer and I understood her behaviour and kept aloof.

After return to India in 1972, I was still getting New Year eve cards from Felicia. I visited Paris again in December 1977 during my trip to ICTP. I got Felicia's address from her sister and called her. She invited me to dinner. Felicia had finished her doctoral thesis and was looking for a job. She was still single

but living in the company of an Italian boy. I returned to the Indian hostel after the dinner.

During 1987, I was travelling with my wife in Europe. I called Felicia from Salzburg (Austria) from the house of my niece, Nina Grewal. She bluntly told me not to call her again as she was now a married woman. I congratulated her on her marriage. In acceptance of my good wishes, she revealed that her life partner is from Netherland and they are both living in Paris. I told her about my visit to Europe with my wife and asked her to stay online. Ranjit Virk, my wife, also conveyed the best wishes on her marriage. Felicia thanked my wife and told her never to doubt my fidelity as a faithful husband. We both went to Paris during this trip but did not call upon Felicia respecting her wishes. I lost track of Felicia after 1987 and our friendship became fossilized.

Labiba Chhamon of Brazil: Labiba was a resident of Brazil hostel on International campus and we used to travel by the same morning bus to Marie Curie university located at Jussieu in Paris. She was working as a secretary to some professor in my university. We also used to meet in the university restaurant at lunch time. Normally, I was always late for my lunch due to the rush of work in my laboratory. It was a French habit to go for a cup of coffee after the lunch. I was not fond of coffee and skipped it to return to my work. One day, Labiba spotted me at lunch time and invited me for a cup of coffee. I accepted her invitation but opted for a cup of hot tea with milk. Labiba also changed her order from coffee to tea. She wanted to know about my personal life in Paris. I told her that I am working in Prof. Max Morand's laboratory for my doctorate in Nuclear Physics. She was working in an office in an adjacent block.

As usual, I took my tea with a lot of milk, which is not the French habit. When Labiba wanted to pour milk from my milk pot into her cup of tea, I intervened asking why she is

going against her natural habit. I pleaded that she has a reservoir of milk in her body to be tapped. My casual remarks made without any bad intention made her emotional and she opened up her mind to me. Labiba's Canadian boyfriend was mentally disturbed and left her without informing. She was hunting for a new friend and I was guessing the motive of her moves to enter into friendship with me. After this meeting, Labiba started to meet me at lunch time regularly. She belonged to a large family of Sao Paulo in Brazil with five brothers and three sisters. Her younger sister, Habiba Chhamon, was also studying in Paris and living happily with her boyfriend.

One day, after our lunch, Labiba proposed to go to a nearby park on the Seine river but I refused, being busy with my research work. On the following week-end, she proposed to visit another park on the periphery of Paris. I accepted her invitation to go along. We took the metro and reached the park for a long walk. Then we went to the nearby tuck shop for a cup of tea. Labiba wanted to spend the evening in my company but I did not agree, feeling her romantic mood.

During the Tulip festival in the Netherlands, a private trip was organised by the university students. Labiba had booked her seat in this tour. She came to inform me about this trip in my Indian hostel. I agreed to accompany her if some vacant seat was available. She took me along to the office of the booking agency and pleaded on my behalf for a seat. With a lot of persuasion, she got my seat booked on the same bus for the night journey from Paris to Amsterdam. We reached Amsterdam in the wee hours and checked into a small hotel for some rest. Labiba's sister was also in our group with her boyfriend. We spent the whole day together, first visiting a Tulip garden in the countryside and then going around the hippie boats, museums and markets of Amsterdam. We returned to Paris by the round trip bus service during the night.

There was a dance festival in the Brazil hostel to celebrate the Carnival of Sao Paulo in Paris. Labiba came to invite me to the dance. The same moment, I received a letter from my wife which I kept for reading later in the solitude. I told Labiba that I am not expert in any form of Latin American dance but she insisted on my floor participation with her. On reaching the venue, I started reading my wife's letter and did not bother about Labiba's demand. She was really upset and scolded me for not joining her on the dance floor.

Ultimately, Labiba was convinced that I am not the type of person who could fall into her trap. In our last meeting in the university restaurant, she was feeling depressed. I enquired about her sadness. She opened her mind with such a frankness that I felt insecure and scared. Labiba proposed that she wanted to be a single mother and I should help her in getting a baby. I told her it is not possible in our culture to have babies without marriage. Then she asked me to marry her for three years, the anticipated time of my stay in Paris. To wriggle out of this situation, I assured her that let me get approval and written permission from my wife in India. She retorted how can it be possible when you kept glued to her letter during the dance festival and ignored her (Labiba) pleas to join in the dance. Labiba failed to win my love and I stood my ground against her charm.

Marie Claude of Cannes: I was destined to make many friends during my stay in Paris and in later years during my tours around the globe. I feel my Turban and Sikh appearance was a great attraction for foreigners, in particular, beautiful ladies, and I was determined to keep this asset intact with Guru's grace. I always kept the narrative of Bhai Joga Singh in my mind, how Guru Gobind Singh protected his devoted Sikh when he was on the brink of falling into a prostitute's snare at Hoshiarpur on his way to Anandpur Sahib. That feeling of

protection was always my lifeguard and a morale booster. How I met Marie Claude of Cannes is another interesting episode of my life.

During the summer vacation of 1971, I was invited to participate in a Youth Camp on the theme “Impact of Modern Cinema on the Youth” held at the University of Grenoble. We were about ten Indian participants and our lodging and boarding arrangements were made in the university hostel. I was surprised that it was organised on the pattern of the Cannes Film Festival. The Indian cinema was represented by the entry of film *Pavitar Papi* (Holy Sinner) based on the novel of Nanak Singh of the same title. The director of the film, BR Chopra and Bhisham Sahni, the lead actor and hero, were present at this festival. I met both of them for the first and the last time in Grenoble. The film was dubbed in English and they were looking for someone who could help them dubbing in French. The director of the camp, Gérard Dhenin, contacted Indian students but they were not familiar with the contents of the story of the film. I was familiar with the story but my language proficiency was not up to the level of dubbing it into French. However, I accepted to provide a brief introduction of the film to the audience, which I did before its show was held in the university auditorium.

After this event, Marie Claude, the wife of Director Gérard, took a special interest in my hospitality. She was looking after staying arrangements of the campers. I was enjoying my stay and joined campers soirees with wild abandon, keeping my long hair falling freely on my shoulders like French philosophers. Marie Claude became friendly and started sitting beside me in these soirees. Before our departure, I made a trip to Geneva to have a tour of this beautiful Swiss city. On the last day, when we were boarding the train to Paris, Marie Claude appeared suddenly on the platform to give me a parting kiss,

which is a French custom. My Indian colleagues started teasing me that she will not leave me alone. Perhaps, Marie Claude was infatuated with love at first sight. She gave me her address in Cannes and contact number before my departure.

During new year eve of 1972, an official tour of one week was organised for foreign students of universities of Paris in the south of France. This campsite was a holiday home in the French Alps-Maritime region, not far from Nice and Cannes. After reaching the campsite, I called Marie Claude and told her about our programme. The campers were visiting Saint Tropez, the famous beach for nude bathing on the Mediterranean coast of French Riviera. Our route was passing through Cannes, and I made up my mind to drop there to see Marie Claude. It was a big surprise for her and I was entertained to a big feast in the family. She prepared vegetarian food and French delicacy 'crepes', which looks identical to the Punjabi *poorbas* prepared during the rainy season. I met her young kids, who saw a Sikh gentleman for the first time. Marie Claude's husband Gérard was very pleased to meet me. He asked about my religion and culture in addition to my research activities in Paris. After dinner, Marie Claude drove me back to the holiday home.

We made a one day trip to Nice and Monte Carlo in Monaco, which is famous for its gambling casino in Europe. On the night of 31st December 1971, a music and dance programme was organised until the wee hours of the morning. Our group included mostly eligible bachelors who were keen to find dance partners at the new year soiree. I had no such attraction and wanted to join as a mere spectator. However, my Bulgarian friend, Nicolay Dimitrov, wanted my help in finding a dance partner. He knew due to my popularity as a Turbaned Sikh, I will find many young girls as a willing partner in the dance. I could fulfil the wish of Nicolay when a young

girl Annie from the neighbouring village invited me to join in the dance. I let her go with Nicolay who was sitting beside me. This feast of dance went on past mid-night after an exchange of new year wishes with hugs and kisses, without any inhibition, even with strangers. Annie gave her telephone and address to both of us before her departure. I met Annie in 1977 during my second trip to Cannes and refreshed old memories. After 40 years, I discovered my friend Nicolay on facebook. He informed me that he is happily married to Marie-Thérèse, a French lady, and living in Grenoble, where he was employed as a Network Operator in the university.

Marie Claude continued writing letters on my return to India. Our friendship changed into a family relationship. In 1987, I was accompanied by my wife, Ranjit Virk, for a four week trip to ICTP, Trieste (Italy). We took a break from ICTP and went to meet our old friends in France and some relatives in Austria. After meeting my friend, Naresh Pal Singh in Paris, we returned to Italy via Lyon, Cannes, Pisa, and Venice. In Lyon, we met the famous historian of Maharaja Ranjit Singh's regime, Jean Marie Lafont and his Punjabi wife Rehana from Lahore. In Cannes, we stayed for two nights with the family of Marie Claude. Her son, Henry vacated his room for us and moved out to stay with his girlfriend. At dinner, Anne Louise, daughter of Marie Claude, and her boyfriend, Phillipe, joined us for dinner. Phillipe embraced Anne, shared kisses and left. My wife asked me later what a liberal display of love in front of parents? I told her it is an example of an open and transparent love affair of Western society in Europe, which is an anathema to Indian society and Punjabi culture. These cultural trends are finding some sort of acceptability and space in neo-rich Indian families.

Marie Claude took us in her car to some nearby spots around Cannes. She served us vegetarian food and offered gifts

for my family on our departure. The bonds of friendship grew and I found myself comfortable that my wife had joined as an equal partner. Before my retirement, I got a phone call from Gérard that Marie Claude had planned a four week trip to India and she will stay in my house with my family. I received her at Sri Guru Ram Das international airport, Amritsar. She had no carryon bag and her checked-in baggage was left behind at New Delhi airport during the change of flight. She was received in our family with fan and fare. My wife got her two Punjabi suits tailored as an emergency measure until her baggage arrived. She looked like a beautiful Sikh Princess in Punjabi attire.

Marie Claude was interested to visit Agra, Rishikesh, Jaipur and Pushkar. She was fascinated by her visit to Golden Temple and its sacred pool. On the day of her visit, the washing and cleaning of the marble floor were going on inside the Golden Temple complex, Marie Claude slipped and fell down, without suffering any serious injury. She liked narrow lanes of the walled city of Amritsar with its old *havelis* (mansions). We took her to a farmhouse near Jhabal in Amritsar district to show her real life in a Punjab village. Ranjit Virk accompanied her to Patiala and Chandigarh. But her mission was to visit some ashram in Rishikesh and the annual Pushkar Fair in Rajasthan. I forbade her to visit Rishikesh but advised her to see more tourist spots in Rajasthan. She accepted my advice as I assured her that my son, Amar Virk, who was posted in Jaipur will organise her trip. There was a direct train from Amritsar to Jaipur but Marie Claude did not like to travel by AC sleeper. Instead, she opted to travel by ordinary second class to experience the real Indian lifestyle. I was scared that she may not be attacked or looted during the night-long journey. However, she reached Jaipur safe and sound as reported by my son. Here again, she refused to stay in the hotel and opted

for a PG accommodation for the two nights stay.

Marie Claude reached Agra by bus from Jaipur. She enjoyed her visit to the Taj Mahal. She hired a cycle rickshaw in Agra and went around the city. When she ended her tour of Agra city and reached the bus stop to catch the bus for Jaipur, she realized that there is no money in her purse! Without losing a moment, Marie Claude paid the *rickshawala* not in cash but in kind by offering her golden bracelet. Fortunately, she carried her return ticket to Jaipur in her safe custody. I could not attribute this loss to some theft; perhaps, she had not changed enough foreign currency or lost it during her shopping.

Her best trip was to Pushkar Camel Fair, a temple town in Rajasthan. From Jaipur to Ajmer, she travelled by Garib Rath express in an AC coach. She realized the comfort of travelling by AC coach in Indian trains with food service provided on wheels. Pushkar fair delighted her with its rural setting and Rajasthani culture. From Jaipur, Marie Claude returned to Amritsar as planned and we took a sigh of relief on her safe return.

Marie Claude reached Cannes by Air France and Gérard called me to say 'Thanks'. In 2001, I made the longest trip to Europe covering twenty countries by Euro-Rail pass. Of course, Marie Claude was included in my itinerary. She had moved from Cannes to her country home near Toulouse. I travelled from Paris to Carcassonne via Marseille and Marie Claude came to pick me up at the railway station with her younger sister. We made a trip to the holy city of Lourdes, a famous Roman Catholic pilgrimage known for its healing powers. We met her son Henry and his family who was living in Pau, a beautiful historic city near Lourdes before our return to Toulouse.

Marie Claude's father was a medical doctor and he purchased this country house for spending his vacations with

his big family of seven children. Marie Claude purchased it by sharing its price with her coparceners and got it repaired for her living. Its building is in poor condition but she is attached to her ancestral property. I enjoyed my stay in this country home with agricultural farms in the vicinity. On the last day of my trip, she drove me through the French countryside to the nearest railway station from where I boarded the train to Paris.

Last year, I got an e-mail from Anne Louise, that Marie Claude had moved to a town near Saint Tropez, leaving her country home forever. She is not keeping well and her daughter Anne wants her mother to stay close by. Most of my Paris days friends are lost in the haze of time but Marie Claude has become a permanent feature of my life and family. God willing, I am planning a trip to France in near future to see Marie Claude and her family once again.

□

Chapter 7

Some Memorable Events of My Life

The journey of life has not been a straight path for me. It has involved me in sometimes adventurous and other times complicated situations. My life's journey had been quite eventful and an account of many such events has been recorded in the preceding Chapters. But I want to recall some memorable events of my life in this Chapter also.

1. I was born to be a *Sadhu* (Ascetic): When I was just two years of age, my mother saw *jattan* (knotted hair) on my head. My *bhua jee* (father's sister) opened my knots and combed my hair straight. But after some days the *jattan* appeared again. I fell sick after this episode. My mother was scared that opening my *jattan* was a bad omen and it may affect my health. After a month or so, all my hair on the head appeared knotted and I looked like an Indian *Sadhu*. My mother consulted some wise men in her neighbourhood who advised that the *jattan* can be removed after some rituals at the age of five.

When I was five, preparations started for a long trek to a shrine, named after Baba Vadbhag Singh, in the Shivalik hills near Hoshiarpur. It happened in 1946, a year before the Indian partition. I have vague memories of this trip. My mother accompanied by her parents reached Hoshiarpur by train from Lyallpur (now Faisalabad in Pakistan). From the railway station, we hired a bullock cart and reached the shrine after a tortuous journey of eight hours. A fair was going on at the shrine on the occasion of Holi festival and we had to sleep under the open sky during the night. Next morning, my mother took her bath

under the waterfall near the shrine. It is believed that persons possessed by ghosts get rid of evil spirits by bathing under this waterfall.

I was taken to a barber shop near the shrine for shaving off my *jattan* from my head. I started crying seeing my bald head. My mother hugged me closely and assured that my hair will grow longer in a few days. After prayers at the shrine, we returned to our village. My playmates started teasing me by knocking their knuckles at my tonsured head. Before I joined my primary school in 1947, my mother used to tie my hair into a bun on my head. I was transformed from a young *jattanwala Sadhu* to a normal Sikh boy with long hair.

2. Seeing Aurora Borealis (polar lights) in My Village: I was the only son of my mother, hence protected under motherly love and care till I joined the College. When I was eleven years old, I was down with fever for several days. There were neither blood testing facilities nor any primary health centre in my village or its neighbourhood. The fever was of the recurrent variety known as *tayya tap* in Punjab. It used to rise suddenly on alternate days, then coming down to normal. Due to its frequency of recurrence on every third day, it was called *tayya tap*. In Punjab, there is a legend that Guru Amardas, third Guru of the Sikhs, banished this fever from Goindwal, the Guru's abode. To get rid of this fever, a *Katha* (literary composition) used to be recited by a learned Pundit to the patient. When this *Katha* failed to cure my disease, my *Nani* wanted to try some *desi nuska* (primitive cure) from a rural medicine practitioner, called *Hakim*.

The after effects of *desi nuska* proved to be horrible. During the night, I got high fever due to the reaction of this medicine prepared by the *Hakim* from some concoction of metal powder mixed with bone. I kept awake and my head went round circles. I started feeling some ghost is sucking my blood. Then I

visualized some psychic experiences like seeing coloured strings flying in the shape of *Aurora Borealis* (polar lights). My mother kept awake reciting Gurbani and praying for my recovery. During the wee hours, I went into a deep sleep and my fever had gone.

3. Power of Prayer: My mother was a firm believer in prayer. In school days, I learned to recite some hymns of Gurbani by rote. My mother taught me Punjabi and Gurbani at home during my primary school. One hymn from Gurbani “*Tati vao na lagie...*” (even hot wind will not touch your body under the protection of God) was my favourite recitation. Once while returning from my school, we were caught in a thunderstorm, followed by a hail storm. There was no building nearby to get protection. I started my recitation and the hail storm stopped suddenly. I was reassured that my prayer had been effective which did this magic.

I have recounted in detail in Chapter 9, how I rejected the hypothesis of my research supervisor at Marie Curie University, Paris. When all my attempts to prove him wrong failed to convince him, I went into a mode of intense prayer. After the prayer, the next morning, I found an event during scanning of emulsion plate, which was one of the rare ones, not found earlier during eighteen months. The result of the analysis of this event established beyond doubt that my investigations are correct and irrefutable by my supervisor. I was awarded the degree on the basis of my interpretation that his hypothesis is based on wrong assumptions, hence liable to be rejected.

4. Taking *pahul* (baptism) to enter the fold of Khalsa Sikhs: In my school days, my routine started with a visit to local Gurdwara in my village. My mother was a devout Sikh lady who recited her *Nitnem* (daily recitation of Gurbani) early morning while I was asleep. I followed in her footsteps when I

joined the college. During my first year of college, I completed *Sehaj Path* (full recitation of Guru Granth Sahib running into 1430 folios) in one month. I visited Rara Sahib, the abode of Sant Ishar Singh Rarewale, during my final year of high school. Darshan Singh Grewal, a science teacher and my mentor in spirituality, took *Khande-di-Pahul* (Sikh baptism) from Rara Sahib.

After I joined my duties in Guru Nanak Engineering College, Ludhiana, I became a regular visitor to congregations of Sant Rarewale. He used to hold his *kirtan* (hymn singing) sessions in Ludhiana city and impressed upon participants to join the Khalsa fold by taking *Khande-di-Pahul* (also called Amrit ceremony). I kept it postponing till I joined Punjabi University, Patiala in 1965. During 1966 *kirtan* session held in Patiala, I was motivated to join the Khalsa fold along with my mother. We were instructed to follow Sikh Rehat Maryada (SRM), a sine qua non for the Khalsa Sikhs.

In Sept. 1966, I got married in Chandigarh. My in-laws family had army background and they were not rooted in SRM. Hence, I had to make a compromise with my non-baptised wife to maintain my conjugal relations. It is obligatory for both husband and wife to be keepers of SRM. I was not a strict follower of SRM myself. I had abandoned wearing my sword after a few days of *Khande-di-Pahul* ceremony. Travelling by aeroplane wearing a sword had been a big challenge those days. Just before going to Paris, I read a book “Spirit Born People” by Puran Singh, in which he presented his views on Sikh symbols of SRM. I was impressed by his argument: “If Sikh intellect is not sharper than the edge of a sword, then what is the use of wearing it as a mere symbol”? I was reconciled to his argument.

5. My Gandhian Experiment in Paris University: I had read about Mahatma Gandhi’s magnum opus “*My Experiments with*

Truth” in which he used to test his *brahmacharya*, which is defined as the virtue of celibacy when unmarried and fidelity when married, by sleeping naked with young unmarried girls in his ashram. There is a lot of criticism in some recent writings on Gandhi and his fads of *brahmacharya*. I have not been a follower of Gandhian philosophy in my life. It is a mere coincidence that I had to encounter a situation during my stay in Paris university, which I may recall as my own Gandhian experiment.

This episode happened in 1971. A Sikh young man from Ganganagar in Rajasthan arrived in Paris with his *fiancé*, a lady doctor from Australia. They reached Indian hostel and met me in its lounge. It was a brief introduction and I never bothered to call them again. After a year, I was working to finish my Ph.D. thesis in June 1972 when the Australian doctor lady approached me in the Indian hostel. She informed that her fiancé is in prison and I should get him released on bail as a guarantor.

She told me that there was a theft in the bank. The robbers ran away and his fiancé was caught due to mistaken identity. Since he could not explain his innocence due to the language problem, he was put behind the bars. First I thought it was a cock and bull story but my friend Ganeshan supported her version. I was told that her fiancé had become clean-shaven and, as a consequence, his identity had been confused with a Moroccan robber by the police on its list. I refused to act as a guarantor for a clean-shaven Sikh who is in prison for a real or concocted theft story.

She was dejected and requested me to allow her to stay in the Indian hostel for one night. She thought of contacting her friend or some relative in England who can act as a guarantor for her fiancé. I accepted her request and allowed her to stay in my room. We went for dinner in the university restaurant. I found she was relaxed after her day-long frustrating experience.

I offered her my bed and opted to sleep on a mattress on the floor. To keep my conscience free from any guilt, I wrote a letter to my wife about this whole episode, before going to sleep. Next morning, I prepared breakfast for both of us and she departed for England. After a week, she came to see me again with her fiancé who was released on bail. They profusely thanked me for timely help. I also thanked her for giving me a chance to test my fidelity and *brahmacharya* in Paris. Gandhi started his experiments on *brahmacharya* at the age of 60, while I did it at 30!

6. An Unfulfilled Wish of My Life: A Scottish proverb and nursery rhyme read: “If wishes were horses, beggars would ride”. Most of my wishes had been fulfilled but my wish to become a Vice-Chancellor (VC) of a university in Punjab remained unfulfilled. I was a candidate for this highest post in the university hierarchy before my retirement in the Guru Nanak Dev University, Amritsar. Some of my well-wishers, even today, ask this question: “Why I failed to become a VC despite my tremendous contributions to academics and research when some other guys with much lesser contribution got it”? To answer their query, I must narrate the secrets of their success and my failure to achieve this coveted post.

It may look strange that for all the posts in the university, right from the peon to the professor, the qualifications are very well defined in the University Calendar and fixed by the state government for non-teaching posts, and by the UGC (University Grants Commission) for the teaching posts. However, for the topmost post of VC in the university administration, there is no such rule. UGC guidelines only suggest that a candidate for VC should be an eminent scholar. But who will determine the worth of his scholarship and its eminence is left to the whims of politicians, generally the Chief Minister (CM) of the state. Another guideline of UGC is to

appoint a Search Committee (SC) which will suggest three candidates for the VC's post and CM will select one out of this list of three. This guideline is generally flouted by all states, either in ignoring it or by rejecting the recommendations of the SC. It is not obligatory for CM to accept the list proposed by the SC. My name was recommended twice, once for the post of VC in Punjabi University (PU), Patiala, and the second time for PTU, Jalandhar, but the list was not accepted by the CM, appointing a favourite candidate of his own choice by throwing all rules of the game to the wind.

Once when I was Dean Academics of GND University, Beant Singh, CM of Punjab, visited the university campus to lay the foundation stone of Applied Chemistry department. It was my duty to receive the CM and I introduced myself as a voter from his constituency. CM was pleased to know it and asked his Personal Assistant (PA) to note my name and contact number so that I have no difficulty in meeting the CM in Chandigarh. As advised, I fixed an appointment with CM through his PA but the Punjab assembly was in session and I had to wait till evening. The adviser to CM, Mr. Harcharan Bains, suggested politely to watch the proceedings of the session from the visitor gallery to kill my time of waiting. There was no end in sight to the ongoing Assembly session and I returned to the Adviser's office.

On my return, I found Dr. J.S. Powar, Pro-VC (PVC) of PU Patiala, sitting with the Adviser. We were old friends of PU and exchanged greetings. Dr. Powar told me about his mission of meeting the CM. He was determined to either get promoted as VC or leave the post of PVC. I knew his relations with Punjab CM were very cordial. Moreover, being a PVC in PU, his chances of hopping up to the post of VC were almost certain. It was getting late and I had no patience to wait for the CM. I understood that my chances are bleak in face of Dr.

Powar and, without a second thought, I moved out of the CM office without meeting him.

For the post of VC in PTU, I met Dr. Upinder Kaur, Technical Education Minister of Punjab, who had been my colleague in PU Patiala. She was impressed by my Curriculum Vitae (CV) and track record in academia. However, she advised me to meet the CM as he is the final authority who wields absolute power in the appointment of VC. Since I had no direct political connection with CM, I asked Randhir Singh Cheema to help me. Mr. Cheema, being an old Akali stalwart from Bassi Pathana, was in good books of CM, Parkash Singh Badal, and he accepted to accompany me for a *sifarsb* (to seek favour). On the day of the appointment, I reached CM house in Chandigarh but Mr. Cheema got delayed due to his engagements at home. On his arrival, he leads me to the presence of CM, who was busy in meeting *sifarsbees* (favour seekers). I was introduced by Mr. Cheema as a close relative and the purpose of my visit explained. The CM listened to my request and informed immediately that the appointment for the post of VC, PTU, had gone in favour of Prof. H.S. Gurm. He told me politely that I had missed the bus due to our late arrival. I understood how and why the scales had been turned in Gurm's favour? While I was waiting to meet CM, I had seen Prof. Gurm walking out of CM house with Mr. D.S. Garcha, who was an influential Akali Minister close to CM, and an old classmate and buddy of Gurm.

Despite these two setbacks, I continued my efforts with perseverance. As luck would have it, when Harcharan Singh Brar became the CM of Punjab, Jagjit Singh Ghumman, who was appointed Professor of Town Planning in GNDU during my tenure of Deanship, wanted to help me. He introduced me to CM through his close relative who was Minister in the Punjab cabinet. The CM kept my application for the post of VC pending

for more than two months. In the meantime, Rajinder Kaur Bhattal, her cabinet colleague and a strong contender for the post of CM, created political turmoil in Punjab. Prof. Ghumman advised me to put political pressure on CM but I had no political links in the Congress at the state level or at the centre.

In the meantime, another candidate, Harbhajan Singh Soch, the ex-Principal of Khalsa College Amritsar took advantage of this situation. He used his political clout and links to get the appointment letter for the post of VC, GNDU Amritsar, issued in his favour. The secret of his success was revealed to me by VC Soch himself. The day I went to congratulate him for his becoming VC, he entertained me by a smile and telling me frankly: “Prof. Virk, you have not tried hard, the scales were in your favour but I tried hard and got the scales tilted in my favour”. I understood that without political influence, no one can aspire to become VC in Punjab and I stand no chance in this rat race.

I continued to dream of becoming VC even after my retirement from GNDU in 2002. The post of VC, PTU Jalandhar, was advertised in 2007. I applied for this post. It was Akali-BJP combine ruling in Punjab. I called my friend, Tarlochan Singh (Ex-MP and Chairman Minority Commission) and requested for help to achieve my target. Next day, I got a call from Tarlochan Singh that he supported my case for PTU but the CM revealed frankly that the post of VC, PTU Jalandhar, had been allotted to BJP. The party can appoint any candidate of its choice. In a few days, when the announcement of the appointment of VC was made in the media, I realised that Tarlochan Singh had been vindicated in his prediction. It was an open secret after Prof. Suresh Arora got appointed to this post in PTU, Jalandhar.

The final act in this sordid drama has yet to be unfolded.

When I applied for the post of VC in GNDU Amritsar for the first time, I was not aware that there is so much corruption in the government departments in the matter of recruitment to both higher and lower cadre jobs. In fact, there was a price tag for all jobs. After my application reached Chandigarh, I got a phone call from some *Dalal* (agent provocateur), that I should keep Rs. five *lakhs* (hundred thousand) ready for payment as a bribe to get the post of VC. Mrs. Virk listened to this call and revealed to me the contents. After half an hour, the agent called me again to tell that he quoted a much lower price, the price tag for VC's post is not five but twenty-five *lakhs*. It was a big shock for me. I rebuked the caller for acting as agent provocateur. He was even prepared to reveal his identity as such deals had become an open secret in Punjab.

The truth of such deals and price tag for all type of jobs under the Punjab government was established soon afterward in my own department. In my earthquake studies project, the post of a driver was sanctioned by the Punjab government at a dismal salary of Rs. 2000 per month. I recruited a retired army jawan, Jaswinder Singh, on this post. One day a *Dalal* reached my office and enquired about Jaswinder, who was a candidate for the post of driver in Punjab Roadways. I directed him to his location outside the university campus. Jaswinder revealed that the *Dalal* visited his house to get Rs. one *lakh*, the amount of bribe settled for this post through the good offices of an MLA of Punjab assembly. Ultimately, Jaswinder got his appointment letter paying the price tag and resigned from my project job. While leaving, Jaswinder retorted: "Sir jee, you failed to pay the price for the post of VC, otherwise you had been sitting in the coveted chair of VC of Guru Nanak Dev University, Amritsar".

My readers, it is a fact of my life, not a fiction. You may ask which party was ruling in Punjab? Let me tell you frankly

all of them behave as '*birds* of a feather *flock* together'. I may provide you one hint and you can make your own judgement. It was Ravi Sidhu era when all posts were having a price tag in Punjab, including those under the domain of Punjab Public Service Commission. Looking back, I feel much relieved that it had been better my wish remained unfulfilled, otherwise I might have been counted in the list of tainted VCs of Punjab. Prof. H.S. Gurm was removed as VC of PTU under corruption charges and put behind the bars. Thank God, I was not subjected to such ignominy in my life.

□

Chapter 8

Literary Journey of My Life

I studied the Punjabi language as my elective subject up to middle school. Master Harbhajan Singh Virk, who was my distant cousin from Kamoke (Gujranwala), advised me to shift from Khalsa High School, Lasso to Government High School, Malerkotla, where Science-Drawing combination was allowed in ninth class. His opinion was this combination will be useful for studying in a professional engineering college. Accepting his advice, I opted out of Punjabi as my elective subject. However, my interest in literature remained intact and I studied most of “The Tales from Shakespeare” by Lamb and Lamb in my high school.

When I entered Govt. College Malerkotla as a student of science, I could hardly cope with my situation at all in face of the hard realities of my life as described in Chapter two. Among my class fellows, Ujagar Singh Kanwal was a budding poet and debater. He used to recite his love songs during lunch break in the college. I was able to memorise most of his songs for humming in free time. In my folk songs, I followed Kanwal’s rhyme and rhythm unconsciously. Moving to Mohindra College, Patiala in 1959 for my B.Sc., I had the good fortune to participate in *Kavi Durbars* (poetical symposiums) held in the college quadrangle. My favourite poets of Mohindra College days were Krishan Ashant, Navtej Bharti and Kulwant Grewal. Harinder Mehboob was my senior in Mohindra college but I was not aware of his literary talents.

Most of my literary activity in Punjabi poetry took roots in this college when I was a hosteller. However, my first

composition was a short story written before entering college life. It remained unpublished till today. During AMU Aligarh days, the classroom teaching and learning of Physics proved to be a boring exercise. Once during the class, I started writing a poem but was caught by the teacher. Before my M.Sc. previous results were announced, I started teaching Science in Khalsa High School, Lassoï during the summer vacation in 1962. Giani Sadhu Singh, the Punjabi teacher and a poet, became my good friend.

One day, Sadhu Singh brought a Punjabi monthly magazine, *Kavita* (Poetry) edited by Vidhata Singh Teer of Amritsar, and started boasting about his poem published in it. In the next issue, he had published another poem. Just to have a fun, I challenged the Punjabi teacher that I shall try my hand at poetry. I wrote a folk song and sent for publication to the editor of *Kavita*. It was published in the same magazine after a month; then I followed suit and published my second folk song. This is how my interest grew in Punjabi poetry.

After joining the teaching career, I was no more involved in writing poetry. However, I was active in writing popular science articles during my tenure in Punjabi University, Patiala. During my stay in Paris, the seeds of Punjabi poetry sprouted again. I wrote two poems and posted to my wife in India as I was feeling like a lovelorn husband. On reaching India, I was so much involved in my research activities, that I had no time to indulge in writing poetry. However, my travelogues were regularly published in local Punjabi magazines and daily newspapers, *Ajit* of Jalandhar and *Punjabi Tribune*, Chandigarh.

During 1992, I was awarded the topmost award “*Shiromani Sahitkar Award*” for my contributions to scientific literature in Punjabi by the Language Department of Punjab Government. My Punjabi poetry was not part of this prize. I kept these poems unpublished for more than half a century. When my

autobiography in Punjabi “*Mera Jeevan Safar*” was ready for the press, I sought the opinion of my friends, Devinder Singh Sekhon and Gurumel Singh Sidhu, who are Scientists as well litterateurs in Punjabi. Both of them gave me a green signal to include a Chapter on my Punjabi poetry in this volume.

The title of my first poem “*Aad sach jugad sach*” is taken from Guru Nanak’s composition ‘*Japu*’. Its main theme is the nature of Truth and Reality, the two pillars of Science and Religion. The search for Truth is the basis of Science. Newton formulated his law of Gravitation on the basis of his observation of the apple falling to the ground. Einstein changed the basic concepts of Space and Time and created his theory of Relativity. This poem refers to the relativity of Truth.

The second poem “Idol Worshipper” is a satire on the Indian intellectuals, who are happy with the status quo. During Emergency in India, imposed on 25th June 1975 by the Prime Minister, Indira Gandhi, civil liberties were totally curtailed. I was witness to its imposition in New Delhi. In this poem, I am the observer (intellectual) walking on the road to PGI, Chandigarh. *Jindua* (soul- mate) is a genre of folk songs in Punjab, which touch the emotional chords. Most of my folk songs express the pining of lovelorn belles of Punjab, hence I find it an uphill task to render these songs into English, due to lack of metaphors in English to express such moods. Most of my folk songs remain un-translated. Surinder Singh Bhatti of Chandigarh, an Architect turned Scholar and Poet, has rendered two *rubaiyat* (quatrains) into English and has given a helping hand in the translation of Punjabi poetry.

Two *Rubaiyat* (Quatrains)

(16 March 1959)

I see lighthouses as they show up through life’s each dark night
My boat may be caught in storms but the shores are yet in sight

How does it matter, friend, if the world has become my enemy
From out of the sorrows' lap I yearn for Thy support my Lord

*

Under thy blue sky's umbrage, a multicoloured world exists
It's sorrows' night at some place; at another joy-hued stupor
Goal eludes even him who sweating his guts out persists
Is this thy world, O God, where life than loaf is cheaper

*

Aad Sach Jugad Sach

(Truth is Everlasting)

1. There is neither beginning nor end of Truth
How can one find the endpoint of a circle?
Truth is neither born nor dies
Time cannot measure the Timeless

2. The Truth of every Age is a witness to that Age
But the Truth still eludes the man
What is the secret of an apple falling to the ground?
Newton started pondering about its Truth
And the law of Gravitation was born
And the search for Truth went into hibernation for centuries

3. Twentieth century is the Age of *Kali Yuga*¹
Guru Nanak spoke that the Moon of Truth is not visible
An Astronaut walked on the Moon
His steps etched "Truth" on the face of the Moon

4. Einstein created his own world of space-time
Newton was proven wrong in its court
Onlookers screamed put Newton's "Truth" to death
His crime was not pardonable
Science (the so-called "Truth") awoke from its slumber of

centuries

When Einstein's "Truth" tore the mist of Time

5. Who says Truth is dead in *Kali Yuga*?

Man has been experimenting with Truth

A sixty-year-old man sleeping with a naked damsel

Calls himself a *brahmachari*² and nobody complained

When I claimed that I tested the same "Truth" at age thirty

They called me a liar!

Because I am no "Mahatma Gandhi"

6. There is a need to protect the Truth in this age

Let it take the fidelity test of fire ordeal again

Science has failed to find the Ultimate Truth

How can they find It?

Who have failed to find the secret of Self

1. *Dark Age*, 2. *a celibate*

*

Idol Worshipper

(On the visit of Indian Prime minister to PGI Chandigarh)

Today this road is closed

The queen of India is passing on this road

1. We are idol-worshippers since times immemorial

This is our religion and tradition

In the modern age, there is only one difference

Every Indian has become a worshipper of man, instead of God

2. The security men standing on both sides of the road

Presented a scenario of Indo-Pak war

And a scenario out of Mahabharata episode

Where Draupadi was to be disrobed

How can Sudama meet Krishna in today's durbar?

3. In the modern-day democracy in India
No one is allowed to present *faryaad*¹
The policeman burst out “do you have a pass”?
Pointing to an old woman crossing the road
Only pass holders can move on this road
4. On this road then appears an intellectual
Requesting profusely for permission to move ahead
His son is admitted to PGI
No transport is allowed to move on this route
How can I allow you to move? Policeman blurts
This is a question of my job
How can I sacrifice my family’s livelihood?
For the sake of your son!
5. Receiving this brusque snub the intellectual scurries
Like a swarm of ants along the moving masses
Who will change this sheeplike behaviour?
Which Ghazni will stop this idolatry of man?
1. *Complaint*
*

My Soul Mate (*Jindua*)

(December 30, 1960)

Black clouds are pouring in snowy-white raindrops,
Oh my soul mate, where are you?

1. My mind is flooded with your memories
I see the moon of hope from the dark clouds of life
Let me steal some rays of love
Oh my soul mate
Come and meet me in the moon-lit night

2. Our courtyard is overcast with clouds
Why don't you come for a moment?
My heart is sinking with sadness
Oh my soul mate
Come to meet me

3. There is a *peepal*¹ tree in our courtyard
A *koel*² is singing aloud
Oh my soul mate
I am stung by her sad songs of separation

4. Under *peepal* tree, I spin my spinning wheel
And like the *koel* sing aloud
Oh my soul mate
My gaze is riveted to the path of your return

5. On our parapet a crow is cawing
And my spinning wheel makes a shrieking noise
Oh my soul mate
When will you return to end my wait?

1. *Ficus religiosa* 2. *Cuckoo*

*

East and West

(In Memory of Rudyard Kipling)

1. Once an English poet wrote
"East and West can never meet"
It is an obvious fact
How can two poles of earth come together?

2. Once an English poet wrote
"East and West can never meet"

It is an old story
It is a thing of the past.

3. Today our hearts beat in harmony
Unequal divisions are removed
East has merged with the West
As space and time have merged
As water with water merges
Then, why an English poet once wrote
“East and West can never meet”

*

A Parisian Beauty Sun-bathing near Indian Hostel

1. A delicate beauty undresses herself
Spreads over the soft grass
The Sun hides behind the clouds
So that beauty is not scorched
We poor Indians are afraid to watch
We are afraid of our nakedness
Parisian beauty was feasting on the rays of the sun

2. She was surrounded by her friends
Moon was illuminated by her beauty
Fragrant breeze was creating its music
Flowers took it for the singing of wasp
We (Indians) were watching the scenario
To catch a glimpse of the nude beauty
Parisian beauty was feasting on the rays of the sun

3. In this colourful world of beauty
Celestial beings sit together
We earthly beings keep moving around
We are confined to the dark alleys of ignorance
We are afraid of the light of new knowledge
Parisian beauty was feasting on the rays of the sun

Night of Separation (*Hijr*) is Endless

(June 2, 1963)

1. Night is dark and my travel is long
How to cover this distance, oh my soul?
As I walk towards my destination
My destination runs away, oh my soul
Ray of hope yet shines
Though clouds of despair cover mind's sky, oh my soul
The night of separation is endless
I keep burning millions of lamps of hope, oh my soul
2. It is twilight and sun is preparing to rise, oh my soul
It distributes light to earthly beings
I also hope for a ray of light, oh my soul
It distributes happiness to all people
But only sorrow is my destiny, oh my soul
The night of separation is endless
I keep burning millions of lamps of hope, oh my soul
3. In dark night I watch a falling star
It approaches earth as its destination, oh my soul
If my star of life shoots
To which destination will it fly, oh my soul
I do not know the secret of a falling star
Nor do I know the secret of my life's star
Then, who will make me understand, oh my soul
The night of separation is endless
I keep burning millions of lamps of hope, oh my soul
4. The face of moon is downcast
As if it had been weeping all night, oh my soul
The tear-drops become stars in the sky
The rising sun removes these tears, oh my soul

In a similar way, the sun of my heart will rise
To remove my life's sorrows, oh my soul
The night of separation will soon be over
I have kept burning millions of lamps of hope, oh my soul

❧

Chapter 9

From Cosmic Rays to Elementary Particles

I was fascinated by the study of Cosmic Rays after reading a B.Sc. level textbook: “Modern Physics” by J.B. Rajam, which included the image of Piara Singh Gill (PS Gill). The footnote mentioned that PS Gill is the discoverer of Latitude Effect of Cosmic Rays. I was motivated to join Aligarh Muslim University (AMU), Aligarh for my Master’s degree in Physics by Gurbax Singh Narang, our Physics teacher in Government Mahendra College, Patiala, who had once tried to register for Ph.D. in AMU under PS Gill. In July 1961, I was admitted to M.Sc. 1st year in Physics at AMU Aligarh. Just after my admission, PS Gill left for a trip to the USA to carry on his research investigations on Cosmic Rays there. On his return after a year, he started teaching our class the Special Paper “High Energy Nuclear Physics”, better known as Elementary Particles.

During the 1960s, research was yet in its infancy in Indian Universities and infrastructure facilities were lacking. However, TIFR (Tata Institute of Fundamental Research) in Bombay was rated among the topmost in the area of Cosmic Rays due to the contribution of Homi J. Bhabha, its director and future architect of Atomic Energy of India. Dr PS Gill, who was my favourite teacher in AMU Aligarh, also joined TIFR during mid-1940s and started using balloons for the study of high altitude effect of Cosmic Rays. As the saying goes: “two swords cannot stay in the same sheath”, the two scientists soon separated due to personal rivalry and Gill moved to AMU Aligarh in 1948 to set up his own independent Cosmic Ray research laboratory at Gulmarg in Jammu & Kashmir state.

I met PS Gill on 21st June 1961 at his official residence in AMU and told him about my plans to join M.Sc. in Physics under his supervision. He was reluctant to accept my proposal and told me about his forthcoming visit to the USA for one year. I felt discouraged. But as luck would have it, I met Bhai Amar Singh, a philanthropist of Aligarh, who offered that I stay in his house till I get admission in AMU. I joined AMU Physics Department at the end of July 1961. Dr. Gill returned from the USA and started teaching us Cosmic Rays and Particle Physics. He was using his notes mostly based on Bruno Rossi's book "High Energy Particles".

The subject of Cosmic Rays was fascinating and we were delighted to find that Homi Bhabha had made some unique contribution to the study of extensive air showers through Bhabha and Heitler Cascade Theory of Cosmic Showers theoretically and later by the study of these showers experimentally. The contributions of Calcutta University for recording tracks of Cosmic rays using Cloud Chamber and nuclear emulsion plates were also considered to be pioneer work in the area of Cosmic Rays. DM Bose and Bibha Chowdhury of Bose Institute studied the meson production in Cosmic Rays at the same time as CF Powell in Bristol University, Bristol, who got the Nobel Prize in 1950 for the discovery of Pi-meson.

I started my teaching career at Guru Nanak Engineering College, Ludhiana in 1963. In 1965, I joined Punjabi University, Patiala. The research in the Physics Department was in its offing and I was assigned to teach a Special Paper "Cosmic Rays and Particle Physics". This experiment failed as there were no research facilities in the department. Punjabi University was set up to teach Science and other disciplines in Punjabi medium. To promote Science in Punjabi, I translated Arthur Beiser's book "The Story of Cosmic Rays" into Punjabi

(*Brahmandi Kirna Di Kahani*) which was awarded the first prize of Punjabi University, Patiala under medium switchover programme.

After 5 years teaching in the University, I became eligible to go for higher studies leading to a doctorate in Physics in a foreign university. I was exploring some avenues both in India and abroad. First, I contacted Prof. MS Swamy who was deputed by TIFR to supervise research in Punjab University, Chandigarh in high energy physics. Then I met Prof. Yog Prakash of Jammu University, a former student of PS Gill from AMU, who had Post-Doctoral training in Cosmic Ray Physics from the USA. Somehow, I did not feel motivated to work in India after my meetings with both Swamy and Prakash.

In 1969, I was selected under Indo-Russian collaboration to study at Moscow State University but this scheme was cancelled at the last moment. In 1970, I qualified for Indo-French Exchange Programme and joined Marie Curie University, Paris for my doctoral research. During the interview held in Alliance Francaise at New Delhi, I was asked about my choice of workplace. I mentioned Cosmic Ray Laboratory (Laboratoire du Rayonnement Cosmique) at *Pic du Midi* in South of France. But, I had no letter of recommendation from its Director. Hence, my choice fell on Laboratoire du Physique Generale, where Professor Max Morand, its Director, accepted me as his Doctoral student. I was helped in my search by Dr. Sham Lal Malick, a Scientist at Marie Curie University, who happened to know Max Morand.

Prof. Max Morand had done his doctorate on Cosmic Rays during the time Pierre Auger was working on extensive air showers in France. He was on the verge of retirement and not interested to undertake fresh graduates in his Laboratory. He accepted me on the condition that I shall have to work under the supervision of a Chinese scientist, Tsai Chu, who was a

Research Scientist in his Laboratory for the last 20 years. He issued me a letter for my Scholarship office that I need not go to an outside institute in Rouen for learning the French language. I could do it in Paris alongside my scientific research. This was a great relief and time-saving device for me as I could focus on my research within three days of my arrival in Paris. Ultimately, I could finish my Thesis just in two years because of this arrangement allowed as a special concession in my case.

Search for an Elusive Particle: I started my research under Tsai Chu who was a man of few words and introvert type of person. He advised me to scan nuclear emulsion plates exposed to 14 GeV proton beam available from 27 GeV CERN Synchrotron. It was a very tedious job. Ms. Thibaut was a Scanner to help me learn this technique but she never bothered to provide me assistance as she was acting as a typist to Director of our Laboratory, Max Morand. My objective was to study Proton-Nucleus interactions using nuclear emulsion as a detector. These interactions are recorded as Nuclear Stars in the emulsion plates. Most of the nuclear stars were consisting of black and grey tracks. My purpose was to find stars with the least number of black tracks. After about 6 months, I had found nearly 200 nuclear stars with nearly a dozen of my interest, which I classified as white stars having relativistic particles as their prongs. The range and grain density of nuclear tracks were studied using Koristka Microscope, an Italian make with automatic recording facility on paper tape to be used in a computer.

This work was demanding and I had to make routine grain density and multiple small-angle scattering measurements for 8 to 10 hours daily. The relationship between energy loss due to ionisation of charged particles and grain density of nuclear emulsions was well established and researchers had to depend upon the empirical curves provided by W.H. Barkas. I was provided a link to the IBM 1620 Computer where we used punch card technique for loading our recorded data. Can you

imagine the speed of this computer was so slow that I had to spend the whole night in the Laboratory for running data tapes? These days a programmable calculator can prove to be more efficient compared with those IBM machines. Every month, I discussed the results of my investigations with my supervisor.

Tsai Chu had spent almost 20 years working on Cosmic Ray and Particle track studies in emulsions. He claimed to have set a world record in manual counting and measurements of track lengths using optical microscopes. His other claim was inspiring and my motivation to carry on with nuclear interactions using high energy proton beams. Tsai Chu had predicted the existence of a heavier Lepton, L-meson particle, with mass in the range of 780 MeV and which decayed into 4 lighter particles, as a resonance decays. I had a doubt about the prediction of Tsai Chu. Initially, I accepted his opinion and faithfully worked with full devotion to establish the validity of his prediction. But later on, I lost my faith in his proposal as all high energy particles emitted in my nuclear stars were identifiable as already discovered. Most of these proved to be relativistic Pi or K-Mesons. Tsai Chu was not prepared to accept my results. Hence, I felt frustrated and depressed.

To resolve this controversy, I planned to visit Rutherford Laboratory in Cambridge University, where a High Energy Physics Group has indirectly supported the prediction of Tsai Chu. I had no prior appointment with the Cambridge group. Reaching London, I made a contact on phone and was invited for an open discussion. I presented my results with the help of slides and was curious to know the opinion of Cambridge scientists. After my presentation, they assured me that they no more support Tsai Chu as their own results were also negative. I was relieved of a great predicament.

On reaching Paris, I met Prof. Max Morand and told about my interaction with the Cambridge group. He was having his

own doubts about Tsai Chu's prediction and allowed me to go ahead with the conclusions of my investigations in an objective manner. Since Tsai Chu was my Research Supervisor, hence his permission was obligatory to submit my doctoral thesis. As a last resort, I made up my mind to make a last attempt to reject the prediction of Tsai Chu. In a mode of prayer, I started to look for a 'White Star' in my emulsion plate and my prayers were answered when I found it with all 14 particles identifiable as already discovered, without an iota of doubt. I presented my results to Tsai Chu but he was reluctant to accept it. In a huff, I met the Director of my Laboratory who encouraged me to publish my results in a research journal before submitting my Thesis. Before my return to India, I published 5 Papers based on my Thesis, one in Nuclear Physics and four others in the Comptes Rendus (Proceedings of the Academy of Sciences, Paris). My Thesis title reads in French: "Identification des particules elementaires produit dans p-N interaction a' 14 GeV/n dans un emulsion nucleaire", which will read in English: "Identification of Elementary Particles produced in p-N interaction at 14 GeV/n in a nuclear emulsion".

It was summer vacation and I made up my plan to write my thesis. I was not confident that I can prepare its copy in the French language as per the terms and conditions of my registration at Marie Curie University. I wrote introductory Chapter in English and got it translated into French by my colleague, Madam Lory. Most of the other Chapters on discussion and results, I wrote myself in French. Prof. Max Morand was highly impressed by the quality of my Thesis and wrote a note of appreciation that it was written in flawless French. I submitted my Thesis in mid-June and went for my tour of European countries. My defence of Thesis was held on 26 September 1972 in the presence of my colleagues and other friends as the defence is open to the public as per French tradition. Professors Max Morand, Mrs. Morand and Louis Avon

from the University of Clermont Ferrand were members of the Jury. After my presentation of more than one hour, my examiners asked some questions and I had to answer in French. I managed to hold my fort during defence with flying colours. Tsai Chu asked a ticklish question about the work of a Russian scientist supporting his prediction which I could handle with the utmost confidence. The Jury was so much impressed that they recommended my Thesis for D.Sc. degree but my tenure at the University was less than the stipulated period of 3 years for this degree, hence I was denied this rare honour.

As per French custom, the award of Doctorate degree is celebrated by a champagne party. My Arab friend from Tunisia, Moncef Fekih, had made all arrangements for the party. He also acted as my Photographer. Naresh Singh and some other Indian scientists of Paris University were also invited on this occasion. My Scholarship was sanctioned for 3 years but I finished my assigned work leading to the Ph.D. degree in just 2 years. I was in a trap: Prof. Max Morand was on the verge of retirement, and Tsai Chu was annoyed with me because my Thesis has demolished his hopes of getting some Award if his prediction of L-meson was established. I was away from my family and a sort of nostalgia overpowered my mind. I decided to return to India to celebrate the Diwali festival on 5th November 1972 with my family. I was in such a hurry that I failed to communicate the date of my arrival in India. I wanted to give them a big surprise!

I was not sure of my return to France as Punjabi University, Patiala, where I held my lien as Assistant Professor had advertised the post of Associate Professor. I was in the queue for promotion. Unfortunately, this post was not filled up till 1975, as my senior in the hierarchy could not complete his Ph.D. and he was able to get our interview postponed till he was awarded the degree. Once in a while, I thought of going back to Paris but then my family was not reconciled to

my viewpoint. I started weighing options. Before my departure from Paris, my Thesis examiner Prof. Louis Avon arranged my meeting with his mentor in research, Prof. Leprince Ringuet of College de France. He advised me to participate in K^0 - anti- K^0 CERN collaboration between India and France as an Indian representative. This turned out to be an uphill task as TIFR Bombay had already recommended some Indian scientist to work in this collaboration. Punjabi University had no facility for experimental work in Particle Physics. So my dream of continuing my research in Particle Physics was shattered due to my logistics problems.

After return to India, I borrowed a stack of emulsion plates exposed to Deuteron beam at JINR (*Joint Institute of Nuclear Research*), Dubna, near Moscow. My intention was to continue some work with Russian collaboration but I found that two more universities in India, namely Jammu and Delhi University, were already working on these stacks. For a year or so, I was shuttling between Patiala and New Delhi to work under Russian collaboration but the research scholar who was employed in this project left me in the lurch. I guided one M.Sc. project in Particle Physics using nuclear emulsions, published 2-3 papers in Journals and decided to abandon my field of interest. Within 2 years, I changed my field from Particle Physics to Geochronology under a Council of Scientific and Industrial Research (CSIR) Project “Dating of Rocks”. This is how my Journey from Cosmic Rays to Particle Physics ended. To keep myself updated in this field, I subscribe to CERN Courier, a window on Particle Physics.

□

Chapter 10

My Journey in Earth Sciences and Creation of Physics Department

Before venturing into Earth Sciences (Geochronology, Geochemistry and Geophysics), I tried my luck for a while to enter the domain of Radiation Biology. For this purpose, I participated in 4 weeks Summer School organised in April 1974 in Indian Institute of Science, Bangalore by the doyen of Biophysics, G.N. Ramachandran, who was once nominated for Nobel Prize in Chemistry by Sir CV Raman, the Indian Nobel Laureate in Physics. I found Biology and Biochemistry contents of the course a hard nut to crack. I collaborated with Dr. Bhagat Singh of Botany department in Punjabi University, Patiala and undertook to investigate the chromosome aberrations in barley seeds exposed to neutron and gamma radiations. We wrote a joint project for funding by the CSIR (*Council for Scientific & Industrial Research*) which was not approved; hence my honeymoon with Radiation Biology was short-lived.

When emergency was imposed by Indian Prime Minister, Indira Gandhi, on June 25, 1975, I was visiting Delhi university to carry on investigations of Deuteron exposed nuclear emulsion plates. On the way back, I happened to visit Prof. K.K. Nagpal's Geochronology Laboratory in Kurukshetra University, Kurukshetra (KUK). Prof. Nagpal had shifted from Particle Physics to Geophysics recently and I found this route a viable choice for me. I knew that my training in microscopy in Paris will prove handy and useful, in the new field of my choice, to study fossil and induced fission tracks. During this visit, I was shown the fission tracks of Uranium in muscovite

mica sheets etched in HF acid by M.K. Nagpal, a research scholar of Prof. Nagpal. It looked so simple and interesting that I decided to make an immediate shift to this field of Geochronology.

Fission Track (F.T.) Dating of Rocks: Fortunately, I was lucky that CSIR, New Delhi, sanctioned me a research project “Dating of Rocks” with some basic grant for equipment and posts of two Junior Research Fellows (JRFs). It was a great morale booster for me as I was the first teacher in Punjabi University, Patiala who was sanctioned two major projects by CSIR and UGC (University Grants Commission), respectively. Sohan Lal Koul and Surinder Singh Parmar joined as JRFs in my project in 1974. In fact, Mr. Koul started working without fellowship by end of 1973 and he got training to etch mineral samples in KUK for a few days. My Geochronology laboratory became functional at a cost of Rs. 2500 only before the CSIR project was sanctioned in 1974. We needed one student microscope, a bottle of hydrofluoric (HF) acid, an etch-bath, a sharp razor blade, and a few strips of mica sheet. The microscope was already available and a bottle of 48% HF acid was purchased from Ambala Cantt. @ Rs. 40 only. Prof. A.K. Prasad of Geology department, PU Chandigarh, supplied us muscovite and biotite samples of Bihar pegmatite belt. Before the end of 1975, we published five research Papers on the dating of pegmatite samples, a great achievement indeed.

Our major problem was the supply of mineral and rock samples. Our scholars had no training in geological field work, hence we had to depend upon supply from Geology departments of neighbouring universities or Geological Survey of India (GSI). On return from Paris, I was appointed as the ‘*Tour Incharge*’ of Physics Department. It gave us an opportunity to collect samples from the areas visited by us. During one such tour to Kathmandu, Sohan Koul collected mineral

samples of the Himalayas in abundance for dating. We found that Himalayan orogeny was the youngest among the mountain ranges of India. But our geologist friends were not happy with our results. We were told that the Himalayas had suffered reverse metamorphism and its geochronology is complex and complicated to interpret. Anyway, we discontinued our studies and shifted our focus to the dating of minerals of Indian pegmatites, found in abundance in most of the states in India. In addition to muscovite mica, biotite and phlogopite, we ventured to date apatite, garnet, zircon, quartz and some other minerals. Surinder Singh and later on his scholar, Amanjit Singh Sandhu, created a record number of publications in the area of Geochronology using fission track dating.

My interest in the study of Tektites was aroused by Robert McCorkell and the book "Tektites and Their Origin" by John O'Keeffe published in 1976. Robert supplied me Glass Dosimeters and Tektite samples for study but to be sure about their origin, I had to purchase a variety of samples from a commercial firm in the USA. Ms. Sukhwinder Kaur did her M. Phil. thesis on Tektites, followed by a publication "Fission track dating of natural glasses" in Nuclear Tracks and Radiation Measurements in 1988. My first paper "Conflicting chronology of Tektites" was published in the proceedings of Third National Solid State Nuclear Track Detectors (SSNTD) Conference held in GNDU Amritsar in 1983. The report of this conference was published in Nuclear Tracks (1983). Using the fission track technique, we dated samples of Obsidians, volcanic glasses from lava flows of Lipari island of Mediterranean basin in Italy, in collaboration with Prof. G. Bigazzi of the University of Pisa. My paper "Fission track dating of volcanic eruptions" was published in Mineralogical Journal of Japan in 1986.

During Oct. 1977, ICTP (*International Centre for Theoretical Physics*) Trieste (Italy) organised a School on Physics of Earth

of ten weeks duration. This was first of its kind outside the area of Theoretical Physics in ICTP. I was keen to participate in this School so that I can venture into inter-disciplinary areas of Earth Sciences with full blast. Prof. A.H. Cook of Cambridge University was Director of this School with other eminent Lecturers from Russia, Japan and Canada. Since our research group in PU Patiala was well established in Geochronology, my selection to this School became an easy affair. The various topics of Physics of Earth were covered exhaustively but my favourite topics were Geochronology, Seismology and Earthquake studies. I never knew that one day my training will be helpful in Earthquake prediction studies using Radon and Helium as precursors. Prof. T. Rikitake from Earthquake Research Institute, Tokyo University, Japan and Prof. V. Keilis-Borok of Moscow were our most sought after Lecturers in this School.

In addition to my training in Physics of Earth (Geophysics), I was lucky on two other counts. I knew Prof. Abdus Salam, Nobel Laureate in Physics, was the Director of ICTP. But I never dreamt that our casual meeting during the inaugural session of this School will turn into an everlasting friendship between two Punjabi scientists. The other count was equally interesting. In those days, participants in ICTP organised Schools were financially supported and allowed to visit other Laboratories in Europe for advanced training in their research areas of interest. I took advantage of this facility to visit Institute de Physique du Globe (*Paris Institute of Earth Physics*) in Paris and the Institute of Geophysics of Graz University, Austria. At both these places, I was invited by Prof. C.J. Allegre and Prof. H. Moritz, respectively, for future collaboration. Before return to India, I made a trip to Tunisia to meet my friend, Moncef Fekih, of Paris university days. I had to catch my return Air India flight from Rome (Italy) which

gave me an opportunity to visit the historic city of Rome and its environs. I also visited Prof. Luigi Tommasino's laboratory situated in the outskirts of Rome city to learn about the techniques of Spark counting of tracks and ECE (Electrochemical Etch) cell fabrication.

Creation of Physics Department at GNDU Amritsar: A turning point came in my Scientific journey on July 10, 1979. I left Punjabi University Patiala after serving it for 14 years to set up a new department of Physics in Guru Nanak Dev University (GNDU), Amritsar. It was a great challenge in my life to create a new department. I had to start from a scratch so far as research facilities were concerned. The teaching of Physics was going on at the subsidiary level of B.Sc. (Hons.) in Chemistry department but Physics Block was being used for administrative purposes as Registrar office cum University Library. We started B.Sc. (Hons.) class in Physics Block by securing possession of three rooms, one for my office, the other for the class room and another for the laboratory. Before leaving Patiala, I was sanctioned a Project "Radon and Thoron Estimation in Soil and Water" by CSIR, New Delhi. The Head Physics at PU Patiala, being my former teacher from AMU Aligarh, allowed me the liberty of transfer of my project funds and the equipment to GNDU, Amritsar without any fuss under CSIR rules.

I was the youngest Head of a department in GNDU and considered to be naive for administration. My training in research took place in Europe and I was not well versed with the tactics of dealing with my bosses in the university hierarchy. Frankly speaking, I did not subscribe to hero worship, better known as *chamchagiri* in Indian parlance. The red tape of Indian bureaucracy is well known. I was wondering why a clerk or an Assistant Registrar commands more authority in pushing files than a University Professor in India. The files were cleared by

the Vice Chancellor only after Registrar office approves the application of Professor or Head of the department. I cannot believe that this is the British legacy as claimed by our politicians. It is unique to Indian democracy which breeds corruption and inefficiency. All my dynamism and motivation to put the department on a fast track suffered due to this bureaucratic system in vogue. It was like a mental torture and my social behaviour changed a lot due to these irritants. However, I kept my cool despite many hurdles created by the university administration. To keep me under bureaucratic tags, a high powered committee was constituted to supervise my activities concerning the purchase of equipment for our laboratories.

Despite these handicaps, we made progress in both teaching and research. We introduced Berkeley Physics Series in B.Sc. (Honours). Research projects were introduced in M.Sc. program. There was a pressing demand for introduction of M.Phil. for College teachers who were seeking eligibility under new UGC rules. During 1979-1983, we had started B.Sc. (Honours), M.Sc. (Honours), M.Sc. (Pass) and M.Phil. programs, in addition to catering for Chemistry, Biology and Electronics departments, supported by a teaching faculty of just 8. The decade of 1983-1993 was horrible for Punjab and our University due to the rise of militancy in Punjab. Amritsar city and Golden temple proved to be its epicentre. The University functioning was affected and our teaching programs got derailed due to local disturbances. Our faculty from other states started moving to safe havens and their replacement became difficult. At this stage, we had to make compromises by recruiting our own Ph.D. qualified candidates to vacant faculty positions. This led to inbreeding and lowering of standards in academia but there was no way out. We could pull on well in Experimental Physics but our Theoretical branch

suffered a lot during this period of turbulence. All my efforts failed to attract some talented faculty from outside the Punjab state.

Before the end of 1990, the Physics department was running four M.Sc. programs. We started M.Sc. Applied Geophysics and M.Sc. Energy Sciences simultaneously without making full preparations for creating infrastructure. These courses had to be closed down after a few years when the job market was not favourable to run these programs. During 1991-93, I was assigned the duties of Dean Academic Affairs and Students Welfare (DAASW) of GNDU, which was a heavy duty job. The university was provided liberal grants by Ministry of Human Resource Development (MHRD) through its agency University Grants Commission (UGC) to start job-oriented courses in the University. The implicit purpose was to wean away young unemployed youth from terrorist activities. We started M.Sc. Applied Physics and many other courses under Applied Science Faculty. I was instrumental in designing course contents and creating infrastructure in the capacity of DAASW with the support of Senior Academics, like Prof. Harjit Singh of Chemistry department. Our Physics faculty strength grew from 8 in 1983 to 22 in 1993 when I exited the office of Deanship.

My Research Collaborations and Conference Participations: Coming back to the activities of my research group after my brief stint of Deanship, our progress was not hampered due to circumstances prevailing in Punjab but the entry of students from other universities became restricted in research. I had half a dozen research students under my supervision. We were lucky to be awarded research projects from various funding agencies, namely UGC, CSIR, DST (Department of Science & Technology), DAE (Department of Atomic Energy) and MEF (Ministry of Environment &

Forests). Before my retirement in 2002, I had served as Principal Investigator of 16 major research projects in India. We had entered into a collaboration with some Universities and Research Laboratories in India and Germany, for example, KUK in India and GSI (Helmholtzzentrum für Schwerionenforschung: Helmholtz Centre for Heavy Ion Research), Darmstadt in Germany. It gave me an ample opportunity to travel to Europe for user committee meetings and presenting our research papers at International Conferences globally.

My first participation in an International Conference took place in Acapulco in Mexico in Sept. 1983. Prof. G. Espinosa was the organiser of this 12th SSNTD (*Solid State Nuclear Track Detector*) Conference in Acapulco, a beautiful holiday resort on Pacific coast. It was my longest journey of 32 hours by air in life with five stopovers between New Delhi and Acapulco. I was dead tired and scared too on reaching Mexico city during midnight. On the whole, it was a memorable conference as I chanced to meet many stalwarts in SSNTD area of research, namely, S.A. Durrani (UK), R.L. Fleischer (USA), R. Brandt (Germany), L. Tommasino (Italy), G. Somogyi (Hungary) and S.L. Guo (China). In fact, Prof. Guo was my room-mate during this Conference. I chaired a session at Acapulco Conference and presented our Single Activation Energy Model of radiation damage annealing in SSNTDs. Later on, I found a group in Australia claimed priority for this model but our paper appeared in the proceedings of 12th SSNTD Conference in 1983; while they published their paper in Nuclear Tracks in 1984.

Thirteenth SSNTD Conference was organised by Prof. Tommasino in Rome during Sept. 1985. In Acapulco, hardly 80 participants attended but in Rome, there were nearly 250 delegates from 40 countries. International Nuclear Track Society (INTS) was set up in Rome to hold these conferences

in future. I was elected as Indian representative of INTS at Rome. It was decided to hold the 14th SSNTD Conference at Lahore in Pakistan which was organised by Prof. H.A. Khan in 1988. It proved to be a blessing in disguise for our group as we presented 20 papers which were the highest number from any group in India or abroad. Our contribution put India at the top with 44 papers in this conference, with the host country Pakistan relegated to number two with 28 papers. Our team enjoyed the hospitality of my friend of Paris days, Dr Asgar Ali, in Lahore. We were offered the official facility to visit Nankana Sahib, the birthplace of Guru Nanak, after the conference. The advantage of these SSNTD Conferences was three-fold: (i) meeting old friends, (ii) exchange of ideas, and (iii) the training of fresh researchers in the art of presenting papers.

My long-lasting friendship with Prof. Abdus Salam proved to be another blessing. Our department was affiliated with ICTP, Trieste for the training of our faculty. Almost all our teachers and some of our research scholars visited ICTP to participate in Workshops or other programs of their interest. A centre of Promotion of Science was set up in GNDU Amritsar with funding from ICTP to popularize Science teaching in rural areas of Punjab. The book “Ideals and Realities” by Abdus Salam was translated by me into the Punjabi language under the title “*Adarsh Ate Haqiqat*”. I had the privilege of serving as Senior Associate of ICTP for five years (1990-95) and visiting several countries under TWAS (*Third World Academy of Sciences*) Fellowship program. My most memorable visits were to Iran, China and Malaysia. These visits gave me an opportunity to contribute in building up research centres in developing countries and the exchange of ideas of mutual interest.

□

Chapter 11

Radon Studies for Uranium Exploration and Earthquake Prediction

During 1975, when my research laboratory in Geochronology became operational in Punjabi University, Patiala, I came in contact with Robert McCorkell, a geologist of Carleton University in Ottawa. He helped me a lot in sending literature concerning my research in inter-disciplinary areas of my choice. He suggested that using simple instrumentation, we can start some research activity in Radon monitoring in soil and groundwater. On the basis of his suggestion, I applied for a project and CSIR sanctioned “*Radon and Thoron Estimation in Soil and Water*” in 1979 for three years at first instance. In those days, I never thought that Radon monitoring and investigations of its health hazards will keep me busy for next twenty years. However, we had a multi-prong approach to our Radon studies and found applications in the Biogeochemical exploration of Uranium, Earthquake prediction research, and Geothermal springs.

On 10th July, I joined Guru Nanak Dev University (GNDU), Amritsar to start a new department of Physics. I shifted my research activities in Geochronology from PU Patiala to GNDU Amritsar. Despite being overburdened by administrative responsibilities, my commitment to promoting research in the newly created department was not diminished. Within a short span of six months, two research scholars, PS Suri, a research scholar from Chandigarh, and SK Modgil, a school teacher from Kapurthala, joined my team. Suri started working under CSIR sanctioned Radon-Thoron project and

Modgil on 'Calibration of Glass Dosimeters', as part of his M.Phil. thesis. My first paper "*Inter-calibration of glass dosimeters for neutron fluence determination*" was published in the International Journal of Applied Radiation and Isotopes in 1980. PS Suri was a Geologist by training and proved to be a great asset in the collection of samples from Siwalik Himalayas for our Radon project. Our first paper "*Uranium and radon estimation by plastic track detectors*" was published in Indian Journal Pure and Applied Physics in 1981.

Our first priority was to set up B.Sc. and M.Sc. laboratories for students and most of our UGC (University Grants Commission) grants were used up for this purpose. However, we were able to import some Glass Dosimeters and Tektite samples from our project grants. It was an arduous task to get the sanctions for the purchase of items from abroad as it involved foreign exchange, which required the approval of Reserve Bank of India. There was always the risk of lapsing of sanctioned grant due to bureaucratic hurdles of University and other agencies. Many researchers felt discouraged to undertake research projects simply because of these hurdles. But I had adapted myself to the environment at the risk of losing my patience.

When our Radon project was at a take-off stage, Mr. Suri left to join his parental department in PU Chandigarh. I was left with no choice but to advertise the vacancy and fill it with a fresh recruit. NP Singh joined us after passing out M.Sc. Applied Physics from PU Patiala in 1982. Manvinder Singh, M.Sc. in Chemistry from GNDU, was also selected on a University fellowship to join my team. He was a great help in starting our investigations using Radon in earthquake prediction studies. Our work involved chemical etching of samples and as a Chemist, he was another great asset. Our paper "*Calibration of radon detectors*" published in Nuclear Tracks and Radiation

Measurements in 1986 is a tribute to his ingenuity and it has been one of the foremost papers on calibration studies in India to be cited by other workers. Tehal Singh joined our team but after one year, he left to join some other department. His paper “*A new track etchant for plastic detectors*” was published in Nuclear Tracks in 1982. We had to discard this useful investigation into new etchants after he left. I recount this story to impress upon new investigators that stability of research group is a necessary condition for producing quality work. By 1983, our research group attained some semblance of stability and we could move forward to achieve our targets.

Radon-Thoron studies were going on along with Fission Track dating and Radiation damage annealing studies by my group. Our main problem was Radon-Thoron detectors which could record Alpha particles with 100% efficiency. Most of the laboratories in India were using the LR-115 Type-2 plastic detector for Radon monitoring. We adopted a multi-prong approach by monitoring Radon in the soil, water, plants, indoor air and outdoor air. Our experiment started on GNDU Campus in the vicinity of Physics department, where we made boreholes to suspend Radon-Thoron discriminator to record Alpha particles on plastic detector sheets. To study the background effect, we monitored Radon in the environment of our recording station. Uranium estimation of the soil at the Radon station site was also done to find a correlation between Radon emission and Uranium. Our first two papers, “*Radon-thoron estimation using LR-115 plastic track detector*”, and “*Uranium and radon estimation in water and plants using SSNTD*” were published in Nuclear Tracks and Radiation Measurements in 1984.

Radon Studies for Earthquake Prediction: Our Radon studies were directed for Earthquake prediction research during 1984 when we observed some anomalies in radon emission in the soil of the GNDU campus. The data was reported at an

International Conference held in Pune University and published in its proceedings in 1986 under the title “*Radon monitoring and earthquake prediction*”. During 1987, Department of Science and Technology (DST), Govt. of India invited proposals under the Earth Sciences Division for major research projects. I considered it as an opportunity to execute our plans for promoting Radon studies in the area of Earthquake prediction research. DST meeting was held in Presidency College, Kolkata where I made my presentation before a high powered committee of Earth Scientists with Prof. V.K. Gaur in the chair. Most of the Investigators submitted proposals to the tune of ten million Indian Rupees. I was asked to revise my proposal and resubmit with an enhanced budget for equipment. It took almost three years when the DST project was sanctioned in 1990 with a budgetary provision of one million rupees, which was beyond my expectations.

Under this project, we imported one dozen Alpha Logger probes from Alpha- NUCLEAR Company of Canada. We had already purchased Alpha-GUARD Radon Monitor (Genitron Instruments GmbH) and Alpha Scintillometer (GBH Electronic) from Germany for soil and water measurements for the field survey. Similarly, we were equipped with Radon-Thoron Discriminator device supplied by BARC, Department of Atomic Energy (DAE), India. Perhaps, we had the best facilities to undertake Radon-Thoron studies and their health hazards to the population in Punjab and Himachal Pradesh (HP); as well as applications to earthquake prediction research in these areas. During the decade of 1990-2000, our research group was running three projects simultaneously: Radon-Thoron studies in soil and water; Radon-Thoron Health Hazard Survey Indoors in Punjab; and, Radon Monitoring for Earthquake Prediction in Punjab and HP. Our team members in these projects were Rajinder Singh, Baljinder Singh, Rakesh

Chand Ramola, Anand Kumar Sharma and Vivek Walia. Radon Survey for Biogeochemical Exploration of Uranium was almost complete in which M. Singh, N.P. Singh and R.K. Ramola participated. In fact, these three members were founding fathers of our Radon network. We undertook Radon monitoring surveys in Punjab and Himachal Himalayas for many years. Our main station was located on the Campus of HPKV (Himachal Pradesh Krishi Vishvavidyalaya), Palampur (HP). At one time, we were running ten Radon monitoring stations in Punjab and HP. I was also a participant occasionally in Radon survey teams during the field work.

There was an unexpected windfall in 1996. The Punjab Government called a meeting of Disaster Management Committee in Chandigarh, chaired by Dr. Manmohan Singh IAS under the aegis of Revenue department. I knew Manmohan Singh since 1965 when he was teaching in Chemistry department of Punjabi University, Patiala. The committee was informed that a grant of Rs 5 million was available in Revenue department for mitigation and management of disasters in the Punjab state sanctioned by the Govt. of India. Since there were no floods or any other disaster occurrence in Punjab during the past three years, this grant may lapse in next two years if not spent for the purpose for which it was sanctioned. I was asked to submit a project proposal which I did under the title, “*Seismo-tectonics and Earthquake Studies in the State of Punjab*”, and a grant of Rs. 2.5 million (25 *laks*) was sanctioned after two expert Seismologists recommended it strongly. We imported equipment for setting up three Seismic stations equipped with state of the art Seismographs.

We collected seismic data for three years at Amritsar, Hoshiarpur and Thein Dam, near Pathankot. Micro-seismicity was recorded in Punjab and Siwalik Himalayas. Our Radon stations were already functioning in these areas. Hence, it

proved beneficial and convenient to record Radon anomalies and find their correlation with seismic activity in the region. During this period, there occurred an earthquake of magnitude 5.7 in the Himachal Pradesh which was strongly felt in Chandigarh. The next day, I was called by the Revenue Commissioner of Punjab (Shyama Mann) to explain why this event was not reported in advance by our monitoring stations? I told her that the seismic signal was recorded at all the stations but a prediction of earthquakes has not yet become possible anywhere in the world. The Commissioner lost her temper in the meeting and ordered to wind up this project if a prediction is not possible. I felt deeply insulted and left in a huff after giving her a bit of my mind. I am telling this episode to show how ill-informed our bureaucracy is towards the needs of Science and Technology in Punjab.

The data recorded by our Seismic stations was so good that our paper "*Estimation of Coda waves attenuation for NW Himalayan region using local earthquakes*" has recorded the maximum number of citations till date in comparison with 400 other research papers published by my group. The only thing which had been bothering us after winding up of the project was that our seismic data recorded on floppy disks will be corrupted and rendered useless for future studies as a benchmark. We failed to transfer seismic data on compact disc (CD) and lost it. Sanjay Sood and his fiancée, Parwinder Kaur, were both engaged in this project to record data on the spot. Telemetry or online facility for transfer of data to our central station in GNDU Amritsar was not available.

We can boast of recording seismic events generated by the nuclear explosions after the underground testing of Atom Bombs by both India and Pakistan during May 1998. It is unfortunate that after the closure of project by Punjab Govt. in 2001, the University failed to provide even maintenance

grant for running it. Equipment worth millions of rupees is rusting without proper maintenance. I enjoyed the status of Director Earthquake Research Centre for five years but my privileges and financial powers were curtailed by authorities of GND University without any rhyme or reason. My experience of running this project ended up in frustration!

During a span of 21 years (1984-2005), our group published 100 research papers under all these projects. The readers may download all these papers from Research gate: www.researchgate.net/profile/Hardev_Virk/publications. The list of papers is available under Appendix I. Most of our Radon research work was presented at International Conferences. Out of my ten highly cited papers on Google Scholar, eight pertain to Radon studies for earthquake prediction. The topmost paper with one hundred citations is: “*Radon recording of Uttarkashi earthquake*” published in Geophysics Research Letters (1994). That confirms the popularity of our Radon studies for earthquake prediction research. It needs to be reported that our Radon studies may be used as benchmark for further investigations in the area of earthquake prediction research in India; though we failed to achieve our target of prediction but found reliable windows for prediction.

To augment our research facilities, DST sanctioned us portable Helium Mass Spectrometer Leak Detector (Alcatel ASM 10) for measurements of Helium concentration emission in soil and water. We imported two sets of equipment for this purpose; one was installed in Palampur and the other in Manikaran (both in HP). However, due to logistic problems, we could not make use of this sophisticated equipment efficiently. Our Radon data was compatible with Helium data in two events recorded in HP. Another useful application of this equipment was made to monitor Radioactivity of Thermal Springs and tectonic features in the Himalayas as reported in

our papers: “Radon/Helium monitoring in some thermal springs of North India and Bhutan” published in Current Science (2002), and “Radon, helium and uranium survey in some thermal springs located in N-W Himalayas, India: mobilization by tectonic features or by geochemical barriers?” published in Journal of Environmental Monitoring (2005).

□

Chapter 12

Heavy Ion Radiation Damage Track Studies in SSNTDs

My training in Marie Curie University, Paris for identification of relativistic particle tracks in nuclear emulsions came handy for shifting to Heavy Ion track studies in Solid State Nuclear Track Detectors (SSNTDs). Track formation mechanism in both may be different but the basic nature of phenomenon by which the tracks are produced remains essentially the same. All charged particles produce ionisation of the medium and lose energy following Bohr's ionisation loss formula. The stopping power is a basic parameter to be calculated which depends upon the charge and velocity of the particle, and the nature of the medium. The other parameters of our interest were range, energy and annealing characteristics of heavy ion tracks in SSNTDs. In 1975, the trio of R. L. Fleischer, P. B. Price and R. M. Walker, considered as the father of SSNTD technique, published their book "*Nuclear Tracks in Solids and their Applications*", which may be considered as a Bible for researchers in the SSNTD field. I had the good fortune to meet this trio and visit their research laboratories after the publication of this book.

The counting of fossil and induced fission tracks was required in Geochronology to find the FT ages of minerals. The counting of Alpha tracks was obligatory in polymer detectors to determine Radon and Thoron concentrations in the media. But in both these areas, we never bothered to study the nature of track formation. Heavy Ion beams became available in India by the end of 1990 after the installation of

16 MeV Pelletron facility under Inter-University Accelerator Centre (IUAC) at New Delhi. During the years I planned the study of Heavy Ion tracks in SSNTDs, we had to depend upon borrowed beam time from UNILAC, GSI, Darmstadt (Germany). I was called to attend the User Committee meeting in GSI held in 1985, which opened the door for entering this domain with acceptance of my proposal.

During 1990, Reimer Spohr was invited as a UGC Visiting Scientist for a month in our university. We held discussions to start a multi-faculty project using Heavy Ions for irradiation of SSNTDs. We prepared a multi-million Rupees project for funding by the DST, which was approved in the first instance. Thangraj of Applied Physics department was my research collaborator. We hoped that the sanction of an Electron Microscope will boost research facilities of the Science faculty but we were surprised that it was cancelled after a review by DST administration. The excuse offered was that this facility is available in the institutions of Chandigarh and could be availed of on sharing basis.

We had been using Fission Fragments (FF) in lieu of heavy ions since 1981. SK Modgil left his job as a school teacher to continue his research leading to Ph.D. By the end of 1981, I was successful in importing a standard Fission Fragment (FF) source (Californium - 252) from the USA for our irradiation experiments. This facility proved to be a great boost for our experimental investigations in the field of radiation damage studies. Modgil took initiative under my supervision to expose soda-lime and other glass samples, and minerals samples to record FF tracks. After irradiation in air and vacuum, the samples were etched using suitable etchants. The track density was recorded by counting tracks under appropriate magnification using a binocular microscope. We published nearly half a dozen papers on the stability of FF tracks under

different thermal conditions. Our Papers “*Efficiency calibration and effect of etchant temperature on fission fragment tracks in soda glass detector*”, and “*Thermal stability of fission tracks in sodalime micro-slide glass*” were published in Int. journal of Applied Radiation and Isotopes in 1982.

Annealing Studies of Radiation Damage and Modgil-Virk Single Activation Energy Model: The highlight of our irradiation experiments were annealing studies of radiation damage in SSNTDs for next twenty years. I guided four more students to study radiation damage in SSNTDs using heavy ion beams from UNILAC facility at GSI, Darmstadt. The beginning was made by Modgil in 1981 using the FF source as stated above. Our investigations led to the formulation of empirical relations (equations) for bulk and track etch rates in SSNTDs (glasses & minerals). When the data was compiled into a paper for submission to a journal, we had the good fortune to invite Prof. Shankar Mukherjee from IIT Kanpur as Visiting Professor in 1982. He examined our paper and took its pre-print to Kanpur. After a week, he informed that an identical formulation has been proposed by a Hungarian Physicist, G. Somogyi, and published his Paper in Nuclear Instruments & Methods B.

First, we thought our labour has gone waste? But Modgil did not lose heart, he had a review of track-etch rate data and analysis of isothermal and isochronic curves of his experiments. He hit upon a new formulation for annealing of radiation damage in SSNTDs, which is known as Single Activation Energy Model of radiation damage annealing in literature. This discovery was reported in 12th SSNTD Conference held at Acapulco in Mexico in 1983, which appeared in the Conference Proceedings under the title “*Track annealing studies in glasses and minerals*” in Nuclear Tracks and Radiation Measurements in 1984. Our paper, “*Annealing of*

fission fragment tracks in inorganic solids”, was published in Nuclear Instruments and Methods in Physics Research B in 1985, which was later on used in its modified form by Prof. P.B. Price and his co-workers in the University of Berkeley in their Space Shuttle Cosmic Ray experiment.

Before we embarked upon the formulation of Single Activation Energy Model of radiation damage in SSNTDs, our laboratory had been engaged in the study of annealing of fossil fission tracks in minerals since 1975 in connection with fission track dating investigations. Annealing of latent radiation damage tracks in various SSNTDs was known to considerably influence etch rates and etchable range of tracks, the critical angle of track registration, and fission track ages of minerals. It was well established that heating of minerals results in the reduction of track densities as well as track lengths and diameters. Thus the study of annealing phenomenon was important for track analysis and understanding the mechanism of track formation in SSNTDs.

The study of Polymer samples exposed to Heavy Ion irradiation was started after having achieved some success with the study of glass samples. Gurmukh Singh guided an M.Phil. student, Shakuntala Devi, and her paper “*Track etch rate characteristics of Makrofol polycarbonate plastic detectors exposed to Xe ions*” was published in Nuclear Tracks and Radiation measurements in 1986. Ravi Chand undertook the investigations of FF and Heavy Ion tracks in Polymers using electrochemical etching technique after developing his own Etch Cell for this purpose. Rajinder Kumar Bhatia started working on annealing of Heavy Ion tracks recorded in Polymers, while Amanjit Singh Sandhu shifted from Geochronology to annealing investigations of Heavy Ion tracks in minerals. Sandhu was instrumental in studying anisotropy of Heavy Ion tracks in mineral SSNTDs after his paper

“Anisotropic etching and annealing studies of fission tracks in quartz” published in Mineralogical Journal of Japan.

We had no inhibition to publish in Indian journals. Our choice of Journals was based on two factors: (i) submission to journals which accept papers without any publication charge, and (ii) where the publication process is rapid. Thus, we had to compromise quality with our convenience, and as a consequence, our publications did not catch the attention of leading groups in SSNTDs. Hence, our original contributions were ignored and our reputation was not established in the field for long. I realised this fact only after my retirement.

Gurinder Singh took the initiative to study Heavy Ion radiation damage effects in glasses using optical absorption spectroscopy. He obtained a modified Best Fit Model of radiation damage annealing in glasses which was an improvement of the Modgil-Virk formulation. This formula was tested for annealing experiments in soda-lime, phosphate and silicate glass detectors to corroborate the concept of a single activation energy in the annealing of radiation damage in SSNTDs. Our paper *“Annealing characteristics of nuclear tracks in glass detectors using optical absorption spectroscopy”* was published in the Journal of Radioanalytical and Nuclear Chemistry in 1994. On the other side of the fence, Rajinder Kumar Bhatia working on Heavy Ion radiation damage annealing in polymers challenged the formulation of Berkeley group and obtained an equivalent version of single activation energy model of Modgil-Virk. An inter-comparison and experimental verification of all these approaches have been reported in my Review paper *“Modgil-Virk Formulation of Single Activation Energy Model of Radiation Damage Annealing in SSNTDs: A Critical Appraisal”* published in Solid State Phenomena Series, Trans Tech Publications (2015).

Without going into the rigorous approach, I may like to

introduce the special features of the Modgil-Virk formulation of radiation damage in SSNTDs. Annealing experiments were carried out to study the dependence of track annealing rate, V_a ($V_a = dl/dt$ or dD/dt), on the temperature and time of annealing. The experimental results prove the exponential dependence of V_a on temperature and a power law type of variation with annealing time. The empirical formulation of this model relates track annealing rate, V_a , explicitly with time and temperature as follows:

$$V_a = A t_a^{-n} \exp (-E_a/kT) \quad (1)$$

where both A and n are ion-dependent constants and E_a , the activation energy, is a unique parameter for a given SSNTD. The special features of this model are:

- (i) It predicts single activation energy of annealing for all heavy ions and fission fragment tracks as required by the Arrhenius equation.
- (ii) It may be used for revealing the thermal history of track-recording SSNTDs (minerals, meteorites and lunar rocks), as annealing rate is given explicitly in terms of both time and temperature.
- (iii) It explains the partial fading of tracks due to environmental annealing as track length is used as a parameter in place of track density.
- (iv) It has universal application. Its validity has been tested for all types of SSNTDs (both crystalline and amorphous) using a variety of heavy ion-beams and fission fragments.

It is unfortunate that Modgil-Virk formulation for Single Activation Energy Model has not been exploited by the research workers to the extent we wished for it. The obvious reasons may be lack of theoretical basis of our empirical formulation as well as lack of publicity. Instead of support, the theoretical group of GNDU Amritsar was involved in a conspiracy in pulling down this Model on the basis of

dimensionality problem of its equation (1). However, Prof. Jayant Narlikar, Director of IUCAA, Pune came to our rescue and suggested a way out of this predicament.

I am pleased to report that a group in PINSTECH (Pakistan) has corroborated our Single Activation Energy Model of radiation damage in SSNTDs in their publication “*Activation energy for the annealing of nuclear tracks in SSNTDs*” published in Nuclear Instruments and Methods in Physics Research B (2001). Their conclusions: (i) Activation energy of annealing of nuclear tracks is a characteristic property of the detector material, and (ii) Single activation energy concept is a good approximation, are identical to what we proposed in our model. Mukhtar Rana is a leading researcher of PINSTECH group to establish this identity.

Heavy Ions were used as a micro-structuring tool by Reimer Spohr of Germany. During his visit to GNDU Amritsar, he left a copy of his unpublished manuscript in our laboratory. When DST project “*Heavy Ion Radiation Effects in Insulators*” was sanctioned, our research team of Gurpartap Singh Randhawa and Sanjit Amrita Kaur was encouraged by me to follow in the footsteps of Reimer Spohr to develop micro-devices using Heavy Ion irradiation of polymers and muscovite mica. Ion Track Filters (ITFs) were prepared and used for environmental pollution studies and filtration of cancer blood cells of cancer patients. We had collaborated with the group of S.K. Chakarvarty in NIT Kurukshetra and Sanjit Amrita got her initial training in the fabrication of ITFs. We were not aware that application of ITFs can prove to be a stepping stone to Nanotechnology of the future in India. It was Prof. R. Brandt of Marburg University (Germany), examiner of Sanjit’s Ph.D. thesis, who remarked in his report that this work can lead to the development of new technologies in India. We published nearly a dozen papers highlighting our contribution. The

following two, published in 1998, need to be mentioned in this regard: “*Effects on insulators of swift-heavy-ions radiation: Ion track technology*” published in Journal of Physics D (Applied Physics), and “*Ion Track Filters: Properties, Development and Applications*” published in Current Science (1998).

Gurpartap Randhawa undertook the study of Heavy Ion ranges and stopping power in SSNTDs and his paper “*Stopping power and range of heavy ions in solids: A comparative study*” was a classic one, which was published in Radiation Measurements (1996) and presented as an Invited Talk by me in the opening session of 3rd Int. Conf. on Material Science Applications of Ion Beam Techniques held at Seeheim, Germany in Sept. 1997. Randhawa was a proficient researcher who got training in Atomic Force Microscopy in CSIO Chandigarh, using this prototype model for the study of radiation damage effects in Insulators (SSNTDs). When R.K. Jain and Ajit Kumar Srivastava from BHU Varanasi joined as Post Doctoral Fellows (PDFs) in our group, we ventured into more diversified areas such as “*Swift heavy ion beam induced modifications in polymers*” using IUAC (New Delhi) Pelletron (accelerator) beams. In addition to physical and chemical property changes, the optical and electrical response of Heavy Ion irradiated polymers (PVDF, PET, Kapton-H, PMMA, CR-39) was investigated using UV, Vis and FTIR spectroscopy. Paramdeep Singh Chandi was a great help in analysing data of modified physical and electrical properties.

After my retirement from GNDU Amritsar in June 2002, I started my collaboration with Rajesh Kumar of AMU Aligarh, presently working in Guru Gobind Singh Indraprastha University, New Delhi. I donated my Heavy Ion irradiated polymer samples along with some unpublished data which was re-investigated by Rajesh and his brilliant research scholar, Paramjit Singh. This collaboration resulted in nine papers in

the area of polymer research, such as “*Study of optical band gap and carbon cluster sizes formed in 100 MeV Sr^{8+} and 145 MeV Ne^{6+} ion irradiated Polypropylene Polymer*” published in Indian Journal of Physics (2009). I may remark in passing that my collaborators in GNDU Amritsar proved to be ungrateful after my retirement and never bothered to acknowledge the guidance or help in their research activity but my collaborators from AMU Aligarh, my alma-mater, never let me down. I learned many lessons about human frailty during my research career of nearly forty years!

□

Chapter 13

My Encounter with Nanotechnology

At the time of my retirement on June 30, 2002, Nanotechnology has not yet become a fashionable area of research in the Indian universities. During 2005, Department of Science and Technology (DST), Govt. of India issued a circular letter to all Universities to send proposals for setting up teaching and research departments in Nanotechnology. Almost fifty universities started this course, including Guru Nanak Dev University, Amritsar. Nanotechnology was not yet a current topic of research in India but it was considered to be an upcoming technology of future worldwide. After my retirement, I moved to Canada to join my sons and their families. However, I returned to India after two months to make India my centre of future activities. I was not inclined to get re-employment but thought of keeping myself busy with writing books and publication work.

During 2005, a Russian scientist, Dmitri Zagorski, visited India to read his paper in an International Conference held in Jaipur. He fell in love with India and asked me to collaborate in his research project under Indo-Russian exchange program to be funded by the Department of Science and Technology (DST), New Delhi. In order to participate in this project, I had to join some University in Punjab. I met Dr. N.P. Singh, Dean Punjab Technical University (PTU), Jalandhar, who was interested in this project but there was no research laboratory in PTU. Hence, this proposal remained in the cold store for lack of any research facility in PTU. Ultimately, I got the offer from DAVIET (DAV Institute of Engineering & Technology),

Jalandhar in 2008 to create a research centre in Nanotechnology. It was a timely offer and I seized upon this opportunity to fulfil my mission.

Before retirement, I started fabrication of microstructures during the 1990s using mica and plastic sheets exposed to heavy ion beams at the accelerator in GSI, Darmstadt (Germany). Ion Track Filters prepared in our laboratory in GNDU were used for purification of water from bacteria and virus contamination, cancer blood cell separation and fabrication of microstructures. Our limitation was the pore size of filters which we could achieve up to a diameter of 1 micron. The experimental technique to reach the nanometer size of pores was not available in India and we had to import the templates from the UK and USA.

It took me six months to set up facilities in DAVIET Jalandhar. Our major equipment was Russian make ND-MDT Atomic Force Microscope (AFM) costing us four million rupees and vacuum coating unit. We imported alumina and polymer membranes from UK and USA, respectively, with pore diameters from 20 to 200 nanometers to be used as templates for the fabrication of Nanowires. In DAVIET Research Centre, our funding was provided by DAV Managing Committee with Rs. 5 million as equipment grant and three posts, two of research scholars and one of a research scientist. Vishal Balouria from NIT Jalandhar joined as a research scholar and Poonam Sharma, Ph.D. in Chemistry from GNDU Amritsar, joined as a Scientist. I made a mistake in proposing low salaries for our research staff as I was not aware of revised grades for researchers by UGC and other funding agencies after my retirement.

Our first experiment was the fabrication of Nanowires of copper by electro-deposition technique. A prototype of electrochemical cell was provided by Ranjit Singh who had

recently finished his Ph.D. thesis in KU Kurukshetra. Kamal Kishore, an Assistant Professor of Physics in DAVIET, assembled all the components required for my experiment. We were not sure of success as it was a topsy-turvy arrangement made in a haphazard manner. I took up the anodic alumina template after electro-deposition of nanowires to Punjab University, Chandigarh to liberate nanowires from the template and record the Scanning Electron Microscope (SEM) images. To my surprise, Nanowires of copper of highest quality were produced in our first trial experiment.

Poonam proved to be a great asset for the preparation of nanocrystals in DAVIET. She prepared various types of nanocrystals, namely, Barium carbonate/oxalate, Barium hexaferrite, Cadmium sulphide, Zinc oxide and Silver oxide, using reverse micelle, microemulsion and co-precipitation techniques. During 2009-11, our laboratory was involved in creating nanocrystals, quantum dots, nanorods and nanowires of various dimensions. Nanoflower fabrication was not on our agenda. This interesting phenomenon was a by-product of our Nanowire fabrication. When our experimental set up failed to produce Nanowires, due to some uncalled for and unintended discrepancy, we were rewarded by exquisite and exotic patterns of Copper appearing as nanoflowers.

In recent years, nanowires and nanorods of metallic and semiconducting materials have drawn a lot of research interest because of their potential applications in diverse fields, for example, nanoelectronics, optoelectronics, and sensors. The special features of nanowires are defined by two quantum-confined dimensions allowing free flow of current in one dimension only. In nanowires, electronic conduction takes place both by bulk conduction and through tunnelling mechanism. It has been discovered recently that nanoflowers have great potential for possible applications in nanotechnology.

Electro-deposition technique used in our experiment is similar in principle to that used for the electroplating process. Commercial anodic alumina membranes (Anodisc 25, Whatman, U.K.) having an average pore diameter of 200 nm, a nominal thickness of 60 micron and pore density of 10^9 pores/cm², were used as templates. The second set of polymer membranes was selected for sake of comparison. Commercially available polycarbonate membranes (Sterlitech, USA) of 25 mm diameter with the pore density of 10^8 pores/cm² and a pore diameter of 100 nm were selected for this experiment. Electrochemical cell used for growth of Nanowires was fabricated in our workshop. The details of the electro-deposition technique used in our experiments have been given in our publications listed in the Appendix I.

There is as yet no specific theory to explain exotic patterns developed during electro-deposition of copper in anodic alumina or polymer templates. A speculative explanation is provided on the basis of over-deposition. During the growth of copper nanowires in the template pores, the current remains nearly stable until the wires arrive at the template surface. If the electro-deposition process is not stopped at this stage, the current keeps on rising very gradually leading to over-deposition of copper. The exotic patterns in the form of micro-flowers having their petals in nanometer dimension, copper buds leading to mushroom effect and double pyramid shaped copper crystals have been observed. Our investigations reveal that chance plays a predominant role in the growth of nanoflowers. One may conclude that fabrication of nanoflowers is an art and lacks scientific explanation. However, there is one satisfaction that all these exotic patterns find some analogue in nature.

In addition to Nanowires, we fabricated Copper-Selenium (Cu-Se) hetero-junctions using anodic alumina membrane,

Cadmium oxide quantum dots by quenching method and studied the effect of CTAB surfactant on structural and magnetic properties of Barium hexaferrite. Rajshree Jatania of Gujarat University, Ahmedabad motivated our group to study hexaferrites during her visit to DAVIET in 2009. During our collaboration, a Review Paper “*Y-type hexaferrites: Structural, Dielectric and Magnetic properties*” was published in a special volume “Ferroics and Multiferroics” in 2012. It has gained a lot of popularity on Researchgate recording 2500 downloads.

During my Editorship of Trans Tech Publications, Switzerland (2011-2016), I edited twelve volumes under two series: Solid State Phenomena, and Defect and Diffusion Forum. I developed a cordial relationship with many authors ending up in collaborations and in writing joint Review papers in a wider number of areas under Nanotechnology. K.V.R. Murthy from MS University of Baroda is a well-known author in the field of Luminescence. Our Review paper “*Luminescence Phenomena: An Introduction*” has been highly cited and downloaded on Researchgate.

□

Chapter 14

My Forays into History & Philosophy of Science and Other Areas

My entry into History and Philosophy of Science was not a planned programme. In High School, I was feeling to be cut out for English literature but my teachers persuaded that I should opt for Science when I topped in Govt. High School Malerkotla in 1957. I still remember the fiery speech of Head Master Khlasa Singh of Khalsa High School, Lassoï to inspire the students to study Science and Mathematics and ignore History which is the easiest subject on earth. When I joined Punjabi University, Patiala in 1965, I was fascinated to study of Cosmology to interpret Guru Nanak's thought about the creation of the Universe. Hakam Singh, the librarian of the university library, impressed upon me to study History of Science also. It stood in good stead in my teaching career as an introduction of the subject with its historic origin proved to be always motivating and inspiring for students.

During 1975, Indian National Science Academy (INSA) organised a Summer School in History of Science in New Delhi with a purpose to start courses at B.Sc. (Honours) level in Indian universities. I was a participant and Prof. DS Kothari, ex-Chairman UGC (University Grants Commission), was chairman of the session in which I presented my Paper. After this School, I was nominated as a Member of UGC Panel on History of Science, even when I was a young Lecturer in Punjabi University, Patiala. A project was also sanctioned in 1977 by UGC but the fellow who joined as research scholar

left me in the lurch.

During 1980, UNESCO organised an International Programme to celebrate the 1,000th birth anniversary of the most influential of Islam's philosopher-scientist Abu Ali al-Husain Ibn Abdallah Ibn Sina, known in Europe as Avicenna. INSA asked me to organise a National Seminar in GNDU Amritsar. I had never read about this Islamic genius. Prof. Gurbax Singh, a historian friend of mine came to my help and I collected all relevant literature on Avicenna. I prepared the key-note address as well my paper "*Ibn Sina's approach to Physics*" which was published in the Indian journal History of Science in 1986. This seminar gave me the impetus to start courses in History and Philosophy of Science at M.Phil. level in GNDU during 1985. Prof. Dhruv Raina, now in JNU, was invited to teach this course.

We were not successful in running a teaching programme in History of Science as planned and it had to be discontinued after 5 years. There was no encouragement from the university and there was hardly any competent teacher to examine our M.Phil. students. However, my foray into this area continued in the form of obituary notes and digging up old records of scientific contributions of Punjabi scientists. I travelled to FRI (Forest Research Institute), Dehradun and collected information about the work of Puran Singh, who was the founder of Chemistry of Forest Products in India. Puran Singh served in FRI as Imperial Chemist for ten years (1908-18) and published 53 notes and papers. My book "Professor Puran Singh: Scientist, Poet and Philosopher" is a tribute to this first Punjabi Scientist who got training in Pharmaceutical Chemistry from Tokyo University during 1900-03.

The other Punjabi scientists who came under my scanner were Ruchi Ram Sahni, Bawa Kartar Singh, Abdus Salam and Piara Singh Gill. Abdus Salam won the Nobel Prize and I

interviewed him in ICTP, Trieste in 1977 before he won the NP. On return, I wrote some articles in vernacular media highlighting his discovery of unification of electromagnetic and weak forces. My article “*Abdus Salam: A grand unifier of men and forces*” was published in a commemorative volume “Abdus Salam: As We Know Him” in 1992. Prof. Salam visited GNDU Amritsar in 1981 and was awarded D.Sc. (Honoris Causa) degree. His convocation address delivered in Punjabi remains a milestone in the history of GNDU Amritsar. I had the privilege to prepare the citation for this degree and to accompany him on his pilgrimage to Qadian. He spoke about his discovery in Urdu and Punjabi on a public platform in Qadian where rural folks assembled to honour a scientific genius among them.

After retirement, I wanted to engage myself full time to History and Philosophy of Science. I discovered Rajinder Singh in University of Oldenburg, Germany, who is a trained Historian of Science, and author of nearly two dozen books. I had written Reviews of his several books. I proposed to Rajinder that we should focus on the contributions of Punjabi scientists who are the products of Lahore School of Punjab University set up in 1882. Rajinder is engaged in digging up the history of Kolkatta School, which has produced Nobel Laureate CV Raman and nearly half a dozen other giants in Indian science, e.g., JC Bose, DM Bose, SN Bose, et al.

Philosophy of Science is another area of my interest. During my M.Sc. studies in AMU Aligarh, I developed some keen interest in Metaphysics and Greek Philosophy. Prof. M.A. Baig, our Warden of Jamal Hostel, was my motivator. He was an Educator and Philosopher of Science. The real impetus came after my Ph.D. thesis in Marie Curie University, Paris. My thesis was a turning point in my life. I opposed the hypothesis of a new Lepton proposed by my Thesis supervisor,

Tsai Chu, and submitted my findings in the form of a thesis contradicting his work. My thesis was accepted by the jury and degree was awarded. But the idea what is “Nature of Reality” in scientific research in general and in the Universe, in particular, never left my mind. I have published some papers and delivered several Seminar talks on this topic. I organised a National Seminar on History and Philosophy of Science in GNDU in 1987 and presented my paper “*Reality: Physical, Metaphysical and Mystical*”. Prof. Yash Pal, the renowned physicist in India, presided over this Seminar and delivered the keynote address.

I have started searching for the solution of the Reality problem in the domain of Religion. I undertook the study of religious scriptures of major religions of the world but my main focus is on the Sikh scripture “Sri Guru Granth Sahib (SGGS)”. I also believe that a Dialogue between Science and Religion is need of the hour for the World Peace. I was a recipient of Honourable Mention Award of Templeton Foundation (USA) for a Project “*Global Perspectives of Science & Sikh Religion*” in 2005. My Paper “*Nature of Reality in Science and Sikh Religion*” was published in the proceedings volume of an International Symposium “*Mastery Meets Mystery: Intersecting Science, Philosophy, Religion and Culture*” in 2015. This topic has been elaborated in my book “*Scientific Vision in Sri Guru Granth Sahib & Interfaith Dialogue*” published by Singh Brothers, Amritsar in 2007.

My teaching career spans over forty years and I am fully conversant with the problems of teaching physics from School stage to University level. I started my foray into this domain during my service in PU Patiala. My survey report “*Teaching of Science in Punjab Schools - A Critical Survey*” was published in NCERT Journal ‘School Science’ in 1976. After retirement, I was elected as President of the Indian Association of Physics Teachers (IAPT) in 2005 during the International Year of

Physics. My association with IAPT started in 1984 and I have contributed more than 2 dozen articles on problems of Science education. IAPT is running its Bulletin since its inception and engaged in innovative laboratory improvement exercise. My paper “*Enigmas (Puzzles) in Teaching and Learning of Physics*” was published in Omni Science in 2016.

The teaching of Science in Punjabi medium was the aim and objective of Punjabi University, Patiala. During my service of 14 years in this university, I wrote 6 books and awarded 3 prizes under medium switchover programme. I was fully devoted to preparing textbooks at B.Sc. level but this scheme fizzled out before its implementation. All these books are rotting in the stores of the university and my labour gone waste.

Popularization of Science was another area of my interest. After my several visits to ICTP, Trieste (Italy) and discussions held with its Director, Professor Abdus Salam, I wrote a proposal for setting up Centre for the Promotion of Science in GNDU Amritsar. This centre was functional for 5 years (1990-95) and I wrote three books for High School students, including translation of “*Ideals and Realities*” written by Abdus Salam into Punjabi under the title “*Adarsh Ate Haqiqat*”. Since there was no matching grant provided by the Punjab Govt., as envisaged under the terms and conditions of the project, we had to close it.

Punjab State is suffering from many maladies mostly created by its own people. After the Green Revolution, the farmers became prosperous in Punjab. The tempo of this revolution is lost and due to over-exploitation of soil and groundwater resources in Punjab, the ecological balance has suffered an irreversible loss. I am presently concerned with Punjab ecology and involved in investigations of Uranium and Heavy Metal hazards to the population of Punjab. My reports are based on groundwater data available with Punjab Water

Supply and Sanitation Department (PWSSD), Govt. of Punjab. However, to avoid adverse publicity and its political fallout, the government officials of PWSSD do not permit me to publish the results of our investigations. A preliminary report is published as an Appendix III to this Chapter.

I started my Postgraduate teaching career from Punjabi University, Patiala in 1965. Last year, I was offered to serve the university as Professor of Eminence, the highest honour for a university teacher in India. It is my pleasure to report that my job entails me to prepare a Concise History of Science in the Punjabi medium from Newton to Stephen Hawking under this assignment.

□

Appendix I

List of My Research Publications

(Copies available on www.researchgate.net/profile/Hardev_Virk/publications)

List of Papers related to Chapter 9 (Elementary Particles & Cosmic Rays)

1. Virk H. S. (1972) Proton-nucleon interactions at 14 GeV in nuclear emulsion. Nucl. Phys. B, 48, 476-486.
2. Tsai-Chu and Virk H S (1972) Energy loss and radiation length of electrons in nuclear emulsion. Compt. Rendu, Acad. of Sciences, Paris, 275, 165-167.
3. Virk H S (1972) Identification of very inclined tracks in nuclear emulsion. Compt. Rendu, Acad. of Sciences, Paris, 275, 517-519.
4. Virk H S (1972) Study of nuclear interaction at high energy. Compt. Rendu, Acad. of Sciences, Paris, 275, 219-222.
5. Virk H S (1972) Do the particles with mass between that of electrons and muon exist? Compt. Rendu, Acad. of Sciences, Paris, 275, 709-711.
6. Virk H S and Bansal B K (1973) Law of gap length distribution and grain density of tracks. Compt. Rendu, Acad. of Sciences, Paris, 277, 65-66.
7. Virk H S (1974) Investigations of Tsytovich radiative corrections to ionisation loss of high energy electrons in nuclear emulsions. Nucl. Phys. B, 72, 393-396.
8. Virk H S (1974) Ionization of ultra relativistic electrons over Fermi plateau. Compt. Rendu, Acad. of Sciences, Paris, 278, 291-292.
9. Virk H S and Verma Veena (1984) Deuteron-nucleus interactions at 10 GeV/c in BR-2 nuclear emulsion. Czech. J. Phys. B, 34, 1032-1037.
10. Virk H S (1979) Cosmic radiation effects in Dhajala meteorite. Curr. Sci., 48, 1067-1068.

List of Papers related to Chapter 10 (Earth Sciences & Related areas)

1. Virk H S and Koul S L (1974) Optical detection of fossil fission tracks in minerals. Compt. Rendu, Acad. of Sciences, Paris, 279, 477-478.

2. Virk H S and Koul S L (1974) Fission track ages of some biotites of Bihar mica belt. *Ind. J. Pure and Appl. Phys.*, 12, 850-852.
3. Virk H S and Koul S L (1975) Fission track ages of some muscovites of Bihar mica belt. *Curr. Sci.*, 44, 211-212.
4. Virk H S and Koul S L (1975) Estimation of uranium in micaceous minerals of Bihar mica belt. *Ind. J. Pure Appl. Phys.*, 13, 569.
5. Virk H S and Koul S L (1975) Annealing characteristics of induced fission tracks in micaceous minerals. *Curr. Sci.*, 44, 341-342.
6. Virk H S and Singh S (1976) Annealing correction to fission track ages of biotites. *Ind. J. Pure Appl. Phys.*, 14, 421-422.
7. Virk H S and Koul S L (1976) Fission track dating and Uranium estimation of some micaceous minerals of Paddar valley, Kishtwar (J and K state, India). *J. Geological Soc. of India*, 17, 547-548.
8. Virk H S and Singh S (1976) Dating of iron ore formations (Calicut area) by fission track method. *Ind. J. Pure and Appl. Phys.*, 14, 868-869.
9. Koul S L and Virk H S (1976) Fission track ages of some Himalayan muscovites. *Geophys. Res. Bull.*, 14, 139-143.
10. Singh S and Virk H S (1977) Annealing correction to the fission track ages of phlogopites. *Curr. Sci.*, 46, 376-378.
11. Virk H S (1977) Origin and age of Tektites. *Curr. Sci.*, 46, 583-585.
12. Virk H S and Singh S (1977) Fission track dating and uranium mineralization in pegmatites of Bhilwara area, Rajasthan state (India). *Mineralogical J. of Japan*, 8, 263-271.
13. Virk H S and Koul S L (1977) Fission track ages of Himalayan muscovites, Kathmandu valley (Nepal). *Pure Appl. Geophys.*, 115, 737-738.
14. Virk H S and Koul S L (1977) Uranium estimation in zircon by using lexan plastic as track detector. *Compt. Rendu, Acad. of Sciences, Paris*, 284, 295-297.
15. Virk H S and Koul S L (1977) Fission track ages and Uranium estimation of Himalayan muscovites, Kathmandu valley (Nepal). *J. Phys. of Earth*, 25, 177-186.
16. Virk H S and Singh S (1978) Inclusion dating and phase differentiation in minerals. *Mineralogical J. of Japan*, 9, 39-40.
17. Singh S and Virk H S (1978) Fission track annealing behaviour of uraninite inclusion in muscovite pegmatite of Bhilwara area, Rajasthan state (India). *Mineralogical J. of Japan*, 9, 111-114.
18. Koul S L and Virk H S (1978) Thermal annealing behaviour of fission tracks in apatite crystal found at Borra mine, Vishakhapatnam District (India). *Mineralogical J. of Japan*, 9, 55-63.

19. Singh S and Virk H S (1978) Fission track dating and estimation of uranium in some garnets of Rajasthan (India). Nucl. Track Det., 2, 169-171.
20. Singh S and Virk H S (1978) Fission track dating and uranium estimation in pegmatite minerals of Rajasthan State (India). Geochemical Journal (Japan), 12, 271-274.
21. Virk H S, Koul S L and Singh S (1978) Fission track geochronology of Eastern Ghats. Geophysical Research Bull., 16, 197-202.
22. Virk H S and McCorkell R (1979) Fission track age of tektites found in recent sediments. Curr. Sci., 48, 679-680.
23. Virk H S and Kaur H (1979) Estimation of uranium in plant and water samples. Curr. Sci., 48, 293-295.
24. Singh S and Virk H S (1980) Fission track dating of copper ore formation of Khetri area, Rajasthan state (India). Geochemical Journal (Japan), 14, 51-55.
25. Virk H S (1980) Inter-calibration of glass dosimeters for neutron fluence determination. Int. J. of Appl. Rad. and Isotopes, 31, 649-651.
26. Koul S L and Virk H S (1980) Uranium estimation in pegmatites using solid state track detector. Czech. J. Phys. B, 30, 778-782.
27. Singh S, Suri P S and Virk H S (1981) Correction for thermally affected fission tracks in glass (obsidian) by age plateau method. Curr. Sci., 50, 626-627.
28. Virk H S (1981) Fission track evidence of ocean bottom spreading. Curr. Sci., 50, 394-395.
29. Singh S and Virk H S (1982) Uranium estimation in minerals and rocks, an application of solid state nuclear track detectors. J. Earth and Space Phys., 11, 1-5.
30. Virk H S, Suri P S and Singh S (1982) Uranium estimation in plants of Siwalik Himalayas, Himachal Pradesh, India. Proc. 11th Int. Conf. on SSNTDs, Bristol (UK) 1981, Pergamon Press, pp.587-590.
31. Singh S and Virk H S (1983) Uranium estimation in Mussoorie phosphorites using solid state nuclear track detectors. Ind. J. Pure and Appl. Phys., 21, 125-126.
32. Singh S and Virk H S (1983) Uranium estimation in some Indian toothpastes. Indian J. Pure Appl. Phys., 21, 550-551.
33. Virk H S (1983) Conflicting chronology of tektites. Proc. 3rd National Conf. on SSNTDs, GNDU, Amritsar, pp.1-7.
34. Virk H S (1983) Conference report on Third Indian National seminar-cum-Workshop on SSNTDs, Amritsar, 7-9 March. Nucl. Tracks , 7, 151-152.

35. Singh N P, Singh M, Singh S and Virk H S (1984) Etching studies of fission damage in quartz. Nucl. Tracks and Rad. Meas., 8, 41-44.
36. Virk H S and Koul S L (1984) Radiation damage dating of apatite and zircon from Eastern Ghats (Andhra Pradesh) J. Assoc. Explor. Geophys., 4, 19-22.
37. Singh S and Virk H S (1984) Fission track dating, uranium estimation and provenance determination of garnets of Cape Camorin sediments, Tamil Nadu (India). Geoviews, 11, 31-34.
38. Singh N P, Singh M, Singh S and Virk H S (1984) Etching studies of fission damage in quartz. Ind. J. of Pure & App. Phys., 22, 496-497.
39. Singh S and Virk H S (1984) Uranium estimation in Toothpastes and Fruit Juices Using Solid State Nuclear Track Detectors. Nucl. Tracks and Rad. Meas., 8, 419-422.
40. Singh S, Sandhu A S and Virk H S (1985) A correction for thermally affected fission tracks in phlogopite mica by Age-Plateau method. Ind. J. Pure and Appl. Phys., 23, 487-488.
41. Singh S and Virk H S (1986) Fission track dating of some apatites from Rajasthan state, India. J. Earth and Space Phys., 15, 1-8.
42. Singh S, Sandhu A S and Virk H S (1986) Etching and annealing studies of fission tracks in phlogopite mica and their application in dating. J. Earth and Space Phys., 15, 9-17.
43. Virk H S (1986) Fission track dating of volcanic eruptions. Mineralogical J. of Japan, 13, 34-38.
44. Singh S, Singh D, Sandhu A S and Virk H S (1986) A study of etched track anisotropy in apatite. Mineralogical J. of Japan, 13, 75-85.
45. Sandhu A S, Singh S and Virk H S (1986) Etching and annealing studies of fission tracks in chlorite and their applications in dating. Mineralogical J. of Japan, 13, 177-186.
46. Sandhu A S, Singh S, Modgil S K and Virk H S (1986) Track annealing studies in some micaceous minerals. Nucl. Tracks and Rad. Meas., 12, 917-920.
47. Singh N P, Singh M, Singh S and Virk H S (1986) Uranium estimation in Siwalik Vertebrate fossil bones using SSTTD. Nucl. Tracks and Rad. Meas., 12, 793-796.
48. Singh S, Singh D, Sandhu A S, Singh G and Virk H S (1986) A study of etched track anisotropy in apatite. Nuclear Tracks, 12, 927-930.
49. Singh N P, Singh M, Singh S and Virk H S (1986) Uranium and thorium analysis in geological samples using plastic track detectors. Nucl. Tracks and Rad. Meas., 12, 883-886.
50. Singh N P, Singh M, Singh S and Virk H S (1986) Method for estimation

- of uranium, thorium and potassium in rocks using gamma ray spectrometry. *Ind. J. Pure and Appl. Phys.*, 24, 565-569.
51. Sandhu A S, Singh S and Virk H S (1986) Etching and annealing studies of fission tracks in chlorite and their applications in dating. *Nuclear Tracks: Application to Earth Science, Space Physics and Nuclear Physics* (Ed. K.K.Sharma) Dehradun (India), pp. 67-77.
 52. Sandhu A S, Singh S and Virk H S (1987) Annealing of fission fragment tracks in micaceous minerals. *Mineral. J. of Japan*, 13, 254-259.
 53. Sandhu A S, Singh S and Virk H S (1987) Anisotropic track annealing in apatite. *Mineral. J. of Japan*, 13, 307-313.
 54. Sandhu A S, Singh S and Virk H S (1987) Annealing studies of fission tracks in apatite. *Ind. J. Pure & Appl. Phys.*, 25, 97-99.
 55. Singh N P, Singh S and Virk H S (1987) Elemental analysis of Siwalik fossil bones using X-ray spectrometry. *Ind. J. Pure and Appl. Phys.*, 25, 411-412.
 56. Sandhu A S, Singh S and Virk H S (1987) Influence of crystallographic structure on the activation energy of fission track annealing in apatite. *Ind. J. Pure and Appl. Phys.*, 25, 499-500.
 57. Singh N P, Singh S and Virk H S (1988) F/á track-etch method for uranium, thorium and isotopic disequilibrium study of geological samples. *Nucl. Track and Rad. Meas.*, 15, 693-697.
 58. Singh S, Singh L, Singh J and Virk H S (1988) Fission track dating of some copper ore formations in India. *Nucl. Track and Rad. Meas.*, 15, 715-718.
 59. Virk H S, Singh G and Kaur S (1988) Fission track dating of natural glasses. *Nucl. Track and Rad. Meas.*, 15, 719-721.
 60. Sandhu A S, Singh S and Virk H S (1988) The effect of anisotropic track etching and annealing on fission track age determination in minerals. *Nucl. Track and Rad. Meas.*, 15, 723-725.
 61. Kaur A, Singh S and Virk H S (1988) A study of uranium uptake in plants. *Nucl. Track and Rad. Meas.*, 15, 795-798.
 62. Sandhu A S, Singh S and Virk H S (1988) Anisotropic track etching in apatite. *Indian J. Pure and Appl. Phys.*, 26, 351-355.
 63. Singh N P, Singh S and Virk H S (1988) A fission track technique used for hydrogeochemical prospecting in Northern India. *Nucl. Geophys.*, 2, 263-267.
 64. Virk H S, Singh G and Bigazzi G (1989) Fission track dating of Lipari obsidians. *Ind. J. Pure and Appl. Phys.*, 27, 187-188.
 65. Singh N P, Singh S and Virk H S (1989) Autoradiographic study of U and Th in quartzites of Kullu area, India. *Nucl. Geophys.*, 3, 119-124.

66. Singh L, Singh J, Singh S and Virk H S (1991) Fission track age of hydrothermal uranium veins in phlogopite and phase differentiation in Minerals. Nuclear Geophysics, 5, 361-364.
67. Singh N P, Singh B, Singh K and Virk H S (1992) Autoradiographic study of uranium and thorium in fossil bones. Nucl. Geophys., 6, 287-291.
68. Bajwa B S, Singh N P and Virk H S (1993) Estimation of uranium and thorium in Siwalik fossil bones. Nucl. Tracks & Radiat. Meas., 22, 851-852.
69. Singh S, Singh L and Virk H S (1993) Correction methods in fission track dating. Nucl. Tracks & Radiat. Meas., 22, 827-830.
70. Singh N P and Virk H S (1993) Natural radioactivity in fossil bones. Proc. Int. Conf. on High Levels of Natural Radiation, Ramsar, Iran (1990). IAEA Publ. Vienna, 1993, pp. 221-228.
71. Bajwa B S, Singh N P and Virk H S (1995) Uranium estimation and isotopic disequilibrium study of Siwalik fossil bones. Nucl. Geophys. 9, 269-272.
72. Bajwa B S and Virk H S (1996) Autoradiography for U, Th, and isotopic disequilibrium study of the Siwalik fossil bones. Environment International (Suppl.), 22(1), 379-382.
73. Virk H S, Randhawa G S and Sandhu A S (1997) Fission track dating of obsidian artefacts from Columbia. Curr. Sci., 72, 884-885.

List of Papers related to Chapter 11 (Radon Studies & its Applications)

1. Singh M, Singh N P, Singh S and Virk H S (1984) Radon-thoron estimation using LR-115 plastic track detector. Nucl. Tracks and Rad. Meas., 8, 415-418.
2. Singh N P, Singh M, Singh S and Virk H S (1984) Uranium and radon estimation in water and plants using SSNTD. Nucl. Tracks and Rad. Meas., 8, 483-486.
3. Virk H S (1986) Radon monitoring and earthquake prediction. Proc. International Symposium Earthquake Prediction-Present Status. University of Poona, Pune, India, pp. 157-162.
4. Singh M, Singh N P, Singh S and Virk H S (1986) Calibration of radon detectors. Nucl. Tracks and Rad. Meas., 12, 739-742.
5. Singh M, Singh N P, Singh S and Virk H S (1986) Radon survey for uranium prospection using alpha detectors. Nucl. Tracks and Rad. Meas., 12, 879-882.
6. Ramola R C, Singh M, Singh S and Virk H S (1987) Measurement of indoor radon concentration using LR-115 plastic track detector. Ind. J.

- Pure and Appl. Phys., 25, 127-129.
7. Singh N P, Singh S and Virk H S (1987) Uranium and radon concentration in Ganges waters in U.P. Himalayas - some preliminary results. Ind. J. Pure and Appl. Phys., 25, 87-89.
 8. Ramola R C, Singh M, Singh S and Virk H S (1987) Efficiency of radon detector LR-115. Ind. J. Pure and Appl. Phys., 25, 235-236.
 9. Singh M, Ramola R C, Singh N P, Singh S and Virk H S (1987) The study of radon diffusion in air and soil. Proc 5th National SSNTD Conf., SINP, Calcutta, p.134-140.
 10. Singh M, Ramola R C, Singh N P, Singh S and Virk H S (1988) Measurement of soil gas radon at Amritsar. Geophys. Res. Bull., 26, 8-12.
 11. Singh M, Ramola R C, Singh N P, Singh S and Virk H S (1988) Influence of meteorological parameters on soil gas radon. Assoc. Explor. Geophys., 9, 85-90.
 12. Ramola R C, Singh S and Virk H S (1988) Radon studies over main boundary thrust near Dehradun (India). Nucl. Track and Rad. Meas., 15, 617-619.
 13. Ramola R C, Singh S and Virk H S (1988) A model for the correlation between radon anomalies and the magnitude of earthquakes. Nucl. Track and Rad. Meas., 15, 689-692.
 14. Ramola R C, Singh S and Virk H S (1988) Uranium and radon estimation in some water samples from Himalayas. Nucl. Track and Rad. Meas., 15, 791-793.
 15. Ramola R C, Sandhu A S, Singh S and Virk H S (1988) Radon measurement in human environment using nuclear track etch technique. Nucl. Data for Science and Tech. Japan JAERI p.1091-1094.
 16. Ramola R C, Sandhu A S, Singh M, Singh S and Virk H S (1989) Geochemical exploration of uranium using radon measurement techniques. Nucl. Geophys., 3, 57-69.
 17. Ramola R C, Singh M, Sandhu A S, Singh S and Virk H S (1989) Radon-Thoron discriminator using polythene foil: An application in uranium exploration. Nucl. Geophys., 3, 137-139.
 18. Singh N P, Singh M, Singh B and Virk H S (1989) A laboratory study of diffusion of radon through soil. Indian J. Pure and Appl. Phys., 27, 46-48.
 19. Singh J, Singh L, Ramola R C, Singh M, Singh S and Virk H S (1989) Radon pollution studies in the environs of radioactive areas using SSNTDs. Nucl. Geophys., 3, 297-298.
 20. Ramola R C, Singh M, Sandhu A S, Singh S and Virk H S (1990) Use of radon gas as earthquake precursor. Nucl. Geophys., 4, 275-287.

21. Virk H S (1990) Radon studies for Earthquake prediction, Uranium exploration and Environmental pollution : A review. *Ind. J. of Phys.*, 64A , 182-191.
22. Singh M, Ramola R C, Singh S and Virk H S (1990) The influence of moisture content on radon diffusion in soil. *Nucl. Geophys.*, 4, 479-482.
23. Virk H S (1990) Earthquake forecasting using radon signals. *Phys. Education.*, 7, 221-228.
24. Singh M, Ramola R C, Singh B, Singh S and Virk H S (1991) Sub-surface soil gas radon changes associated with earthquakes. *Nucl. Tracks and Radiat. Meas.*, 19, 417-420.
25. Ramola R C, Singh M., Singh S and Virk H S (1991) Laboratory studies on the behaviour of radon diffusion through soil. *Nucl. Tracks and Radiat. Meas.*, 19, 389-390.
26. Singh J, Singh L, Singh S and Virk H S (1991) Seasonal variation study of radon pollution at radioactive sites. *Nucl. Tracks and Radiat. Meas.*, 19, 415-416.
27. Ramola R C, Singh M, Singh S and Virk H S (1992) Environmental radon studies using solid state nuclear track detectors. *J. Environmental Radioactivity*, 15, 95-102.
28. Ramola R C, Singh M, and Virk H S (1992) Radon monitoring and earthquake prediction. "Progress in Earthquake Research and Engineering", Vieweg Publication Series, Wiesbaden, Germany.
29. Singh M, Ramola R C, Singh B, Singh S and Virk H S (1992) Radon anomalies: Correlation with seismic activities in Northern India. *Proc. 2nd Int. Workshop on "Radon Monitoring in Radioprotection, Environmental/Earth Sciences, Trieste, Italy (1991). World Scientific, 1993, pp. 359-377.*
30. Virk H S and Singh B (1992) Correlation of radon anomalies with earthquakes in Kangra valley. *Nucl. Geophys.*, 6 , 293-300.
31. Singh B and Virk H S (1992) Radon measurement for earthquake prediction in Northern India. *Trans. Amer. Nucl. Soc.*, 65, 50-52.
32. Virk H S and Singh B (1993) Radon anomalies in soil gas and groundwater as earthquake precursor phenomena. *Tectonophysics*, 227, 215-224.
33. Singh B, Singh S and Virk H S (1993) Earthquake prediction studies in Kangra valley using plastic track recorders. *Nucl. Tracks & Radiat. Meas.*, 22, 459-460.
34. Singh B, Singh S and Virk H S (1993) Radon diffusion studies in air, gravel, sand, soil and water. *Nucl. Tracks & Radiat. Meas.*, 22 , 455-458.

35. Singh N P and Virk H S (1993) Natural radioactivity in fossil bones. Proc. Int. Conf. on High Levels of Natural Radiation, Ramsar, Iran (1990). IAEA Publ., Vienna, 1993, pp. 221-228.
36. Singh B and Virk H S (1994) Investigation of radon -222 in soil-gas as an earthquake precursor. Nucl. Geophys., 8, 185-193.
37. Virk H S and Singh B (1994) Radon recording of Uttarkashi earthquake. Geophys. Res. Letters., 21, 737-740.
38. Virk H S (1994) Scope for radon monitoring for earthquake studies in India. Bull. of Radiat. Protection, BARC, Bombay, 17, 29-32.
39. Virk H S and Singh B (1995) Correlation of radon anomalies with the Uttarkashi earthquake. J. Geol. Soc. of India, 30, 125-132.
40. Virk H S (1995) Radon monitoring of microseismicity in the Kangra and Chamba valleys of Himachal Pradesh, India. Nucl. Geophys., 9, 141-146.
41. Virk H S, Walia Vivek and Anand K Sharma (1995) Radon precursory signals of Chamba earthquake. Curr. Sci., 69, 452-454.
42. Virk H S (1995) Radon recording of the Uttarkashi earthquake. Gas Geochemistry (edited by Claude Dubois) Science Review, Northwood, UK, pp.221 - 230.
43. Singh B and Virk H S (1996) Effect of soil and sand moisture content on radon diffusion using latic track-etched detector. Radiat. Meas., 26, 49-50.
44. Virk H S (1996) A critique of empirical scaling relations between earthquake magnitude, epicentral distance and precursor time for interpretation of radon data. J. Earthquake Prediction Res., 5, 574-583.
45. Virk H.S (1997) Radon studies for earthquake prediction. Himalayan Geology, 17, 91-103.
46. Virk H S, Anand K Sharma and Vivek Walia (1997) Correlation of alpha-logger radon data with micro-seismicity in N-W Himalaya. Curr. Sci., 72, 656-663.
47. Virk H S, Singh M and Ramola R C (1997) Radon monitoring for uranium exploration, earthquake prediction and environmental health hazard in Himachal Pradesh, India: An appraisal. Rare Gas Geochemistry (Ed. H.S.Virk), Proc. 3rd ICRGG held at Amritsar, India, Dec.10-14, 1995, pp. 89-99.
48. Virk H S and Sharma Anand K (1997) Micro-seismicity trends in N-W Himalaya using radon signals. Rare Gas Geochemistry (Ed. H.S.Virk) Proc. 3rd ICRGG held at Amritsar, India, Dec.10-14, 1995, pp. 117-135.
49. Virk H S (1997) Uranium and radon surveys in Siwalik Himalayas.

- IARP Bulletin 20(3), 130-142.
50. Virk H S, Sharma Anand K and Walia Vivek (1997) Correlation of alpha-logger radon data with microseismicity in N-W Himalaya. *Curr. Sci.* 72, 656-663.
 51. Virk H S (1997) Uranium and radon surveys in Western Himalaya. *Curr. Sci.* 73(6) 536-538.
 52. Virk H S (1997) Radioactivity survey in thermal springs of N-W Himalaya. *Proc. 33rd Int. Conf. on Hot Springs (SITH)*, Hakone, Japan, pp. 143-146.
 53. Ramola R C, Singh M, and Virk H S (1998) Radon monitoring and earthquake prediction. "Earthquake Prognostics Strategy- Against the Impact of Impending Earthquakes." Vieweg Publication Series, Wiesbaden, Germany, pp.91-108.
 54. Virk H S (1998) Postdiction of Uttarkashi and Chamba earthquakes using radon precursory signals. *J. Earthquake Prediction Research*, 7, 89-97.
 55. Virk H S and Sharma Navjeet (1998) Indoor radon levels in the radioactive areas of Himachal Pradesh: An intercomparison of active and passive techniques. *Ind. J. Rad. Prot. & Environ.*, 21(2), 103-106.
 56. Virk H S, Kumar Naresh, Sharma Navjeet and Bajwa B S (1998) Alpha-Guard radon survey in soil gas and dwellings of some uranium-rich areas of Himachal Pradesh, India. *Curr. Sci.*, 75, 430-431.
 57. Virk H S, Kumar Naresh and Sharma Anand K (1998) Radon/Helium survey of thermal springs of Parbati, Beas and Sutlej valleys in Himachal Himalaya. *J. Geol. Soc. India*, 52, 523-528.
 58. Bajwa B S and Virk H S (1998) Indoor radon levels in the environs of Guru Nanak Dev University Campus. *Radon and Thoron in the Human Environment* (Eds. Akira Katase & M. Shimo), World Scientific, Singapore, pp. 435-439.
 59. Virk H S (1999) Indoor radon levels the radioactive sites of Himachal Pradesh, India. *Environ. International*, 25, 47-51.
 60. Virk H S (1999) "Radon Measurements by Etched Track Detectors : Applications in Radiation Protection, Earth Sciences and the Environment " by S.A. Durrani and R. Ilic. *Rad. Phys. and Chem.* (Book Review), 54(3), 323-324.
 61. Virk H S, Sharma Navjeet and Bajwa B S (1999) Environmental radioactivity: A case study of Himachal Pradesh, India. *J. Environ. Radioactivity*, 45, 119-127.
 62. Virk H S (1999) Radon/Helium studies for earthquake prediction in N-W Himalaya. *Proc. 4th Int. Conf. on Rare Gas Geochemistry*, Rome,

- Italy, Oct. 8-10, 1997, *Nuovo Cim.* 22, 423-429.
63. Sharma K Anand, Walia Vivek, Kumar Naresh and Virk H S (1999) Helium/Radon studies and its use as a predictive tool for earthquakes in N-W Himalaya. *Proc. XI National Symp. on SSNTDs*, GND University, Amritsar, Oct. 12- 14, 1998, pp. 199-209.
64. Virk H S, Walia Vivek, Sharma K Anand, Kumar Naresh and Kumar Rajiv (1999) Radon anomalies and their correlation with microseismicity in N-W Himalaya. *Proc. XI National Symposium on SSNTDs*, GND University, Amritsar, Oct. 12-14, 1998, pp. 21-36.
65. Virk H S (1999) Radon Monitoring: Opportunities, Challenges and Pitfalls. *Proc. XI National Symposium on SSNTDs*, GND University, Amritsar, Oct. 12-14, 1998, pp. 228-232.
66. Sharma Navjeet and Virk H S (1999) Indoor levels of radon/thoron daughters in some dwellings of Punjab. *Proc. XI National Symp. on SSNTDs*, GND University, Amritsar, Oct. 12-14, 1998, pp. 259-262.
67. Bajwa B S and Virk H S (1999) Natural radioactivity measurements in some Siwalik vertebrates using fission tracks technique. *Proc. XI National Symposium on SSNTDs*, GND University, Amritsar, Oct. 12-14, 1998, pp. 323-327.
68. Bajwa B S, Sharma Navjeet and Virk H S (1999) Study of Indoor radon levels using SSNTDs. *Proc. XI National Symposium on SSNTDs*, GND University, Amritsar, Oct. 12-14, 1998, pp. 252-255.
69. Virk H S and Singh M (1999) Uranium and radon anomalies in the river system of N-W Himalayas. *Ind. J. Environ. Prot.*, 19(10), 750-752.
70. Virk H S and Sharma Navjeet (2000) Indoor radon/thoron survey report from Hamirpur and Una districts, Himachal Pradesh, India. *Appl. Rad. & Isotopes*, 52, 137-141.
71. Sharma K Anand, Walia Vivek and Virk H S (2000) Effect of meteorological parameters on radon emanation at Palampur (H.P.). *J. of Geophys.*, 21(1), 45-48.
72. Virk H S (2000) Environmental uranium and radon surveys in Western Himalaya: A case study in radioactive pollution. *Environmental Protection* (Eds. A.K. Thukral & G.S. Virk), Scientific Publishers, Jodhpur (India), pp. 68-79.
73. Virk H S, Walia Vivek, Sharma K Anand, Kumar Naresh and Kumar Rajiv (2000) Correlation of radon anomalies with microseismic events in Kangra and Chamba valleys of N-W Himalaya. *Geofisica Internacional*, 39(3), 221-227.
74. Virk H S and Sharma Navjeet (2000) Indoor levels of radon/thoron daughters in some dwellings of Punjab and Himachal Pradesh, India. *Proc. IRPA Regional Congress on Radiation Protection in Central*

- Europe held at Budapest, Hungary, Aug.22-27, 1999 (CD ROM).
75. Virk H S and Sharma Navjeet (2000) Indoor radon levels and inhalation doses to a population in Punjab. *Curr. Sci.*, 78, 1418-1420.
 76. Virk H S (2001) Radon/Helium studies for earthquake prediction and fault delineation in NW Himalaya . *Research Highlights in Earth System Sciences: DST's Spl. Vol.2 on Seismicity* (ed. O.P. Varma), Published by Ind. Geol. Cong., 277-288.
 77. Virk H S Walia Vivek and Kumar Naresh (2001) Helium/radon precursory anomalies of Chamoli earthquake, Garhwal Himalaya, India. *Jour. of Geodynamics*, 31, 201-210.
 78. Virk H S and Sharma Navjeet (2001) Radon and thoron survey in the dwellings located in radioactive zones of Himachal Pradesh, India. *Rare Gas Geochemistry* (Eds. I. Hunyadi, I. Csige and J. Hakl) *Proc. 5th ICRGG held at Debrecen, Hungary, Aug.29-Sept.3, 1999*, pp. 135-138.
 79. Virk H S, Walia Vivek, Sharma Anand K and Kumar R (2001) Radon anomalies and their correlation with microseismic events in Kangra and Chamba valleys of N-W Himalaya. *Rare Gas Geochemistry* (Eds. I. Hunyadi, I. Csige and J. Hakl) *Proc. 5th ICRGG held at Debrecen, Hungary, Aug.29-Sept.3, 1999*, pp. 37-42.
 80. Sharma Navjeet and Virk H S (2001) Exhalation rate study of radon/thoron in some building materials. *Rad. Meas.*, 34, 467-469.
 81. Virk H S and Walia Vivek (2001) Helium/Radon precursory signals of Chamoli earthquake, India. *Rad. Meas.* 34, 379-384.
 82. Virk H S (2001) Radon emanometry data and its correlation with microseismic events in Kangra and Chamba valleys. *Proc. 2nd Dresden Int. Symposium on Radiation Protection, Dresden, Germany, Sept. 10-14 (CD ROM)*.
 83. Virk H S and Walia V (2001) A critical analysis of radon emanometry data recorded at Palampur and Dalhousie for earthquake prediction studies in N-W Himalaya. *Bull. Ind. Geol. Assoc.*, 34 (Spl. Vol.1&2), 243-256 .
 84. Virk H S, Walia V and Bajwa B S (2001) Radon monitoring in underground water of Gurdaspur and Bathinda districts of Punjab, India. *Ind. J. Pure & Appl. Phys.*, 39, 746-749.
 85. Virk H S, Navjeet Sharma and B S Bajwa (2001) Enviuronmental uranium and radon surveys in some areas of Punjab, Himachal Pradesh and Uttranchal states. *Proc. 14th National Symposium on Radiation Physics, November 1-3, 2001, G.N.D.University Press, Amritsar*, pp.1-6.
 86. Virk H S and Vastagh George (2002) Forecasts of earthquakes and measuring of radon. *Fizikai Szemle* (Hungary), 2, 53-55.

87. Virk H S and Walia Vivek (2002) Radon/Helium precursory signals of Uttarkashi and Chamoli earthquakes. *Himalayan Geology*, 23, 147-151.
88. Virk H S and Sharma Navjeet (2002) Indoor radon/thoron levels and inhalation doses to some populations in Himachal Pradesh, India. *J. Environ. Monitoring*, 4(1), 162-165.
89. Virk H S, Sharma A.K. and Sharma Navjeet (2002) Radon/Helium monitoring in some natural/springs of North India and Bhutan. *Curr. Sci.*, 82(12), 1423-1424.
90. Virk H S and Sharma Navjeet (2002) Indoor radon/thoron survey in dwellings of Himachal Pradesh, India Proc. 5th Int. Conf. on High Level of Natural Radiation and Radon Areas : Radiation Dose & Health Effects (Eds. J. Peter, G Schneider and A. Bayer), Technical University, Munich, Germany, Sept. 4-7, 2000, 193-196.
91. Walia V, Virk H S, and Kumar Puneet (2002) Empirical Scaling Relationships between Earthquake Magnitudes, Epicentral Distances and Amplitudes of Radon Anomalies in N-W Himalaya. *Ind. J. Pure & Appl. Phys.* 40, 743-749.
92. Walia V, Bajwa B.S. and Virk H S (2002) Radon monitoring in groundwater of some areas of Himachal Pradesh and Punjab, India. *Jour. of Environ. Monitoring* 5, 122-125.
93. Bajwa B S, Virk H S and Singh S (2003) A comparative study of indoor radon level measurements in the dwellings of Punjab and Himachal Pradesh, India. *Radiat. Meas.* 36, 457-460.
94. Walia V, Virk H S, Bajwa B S and Sharma Navjeet (2003) Relationships between radon anomalies and seismic parameters in N-W Himalaya. *Radiat. Meas.* 36, 393-396.
95. Bajwa B S, Sharma Navjeet, Walia V and Virk H S (2003) Measurements of natural radioactivity in some water and soil samples of Punjab, India. *Indoor & Built Environ.* 12, 357-361.
96. Virk H S (2005) Correlation of radon anomalies with micro-earthquakes in Kangra and Chamba valleys of N-W Himalaya. *Kangra Earthquake Centenary Seminar (KECS-2005)*, Special Publ. No. 85, GSI (NR), Lucknow, pp.151-160.
97. Walia V, H S Virk, Yang T F and B S Bajwa (2005) Earthquake prediction studies using radon as a precursor in N-W Himalayas, India: A case study. *TAO (Taiwan)* 16(4), 775-804.
98. Walia V and Virk H S (2005) Radon precursory signals for some earthquakes of magnitude > 5 occurred in N-W Himalaya. *Pure Applied Geophys.* 163(4), 711-721.
99. Walia V, Quattrocchi F, Virk H S, Yang T F, Pizzino, L and Bajwa B S (2005) Radon, helium and uranium survey in some thermal springs

- located in N-W Himalayas, India: mobilization by tectonic features or by geochemical barriers? J. Environ. Monitoring 7, 850-855.
100. Kumar N, Parvez IA and Virk H.S (2005) Estimation of Coda waves attenuation for NW Himalayan region using local earthquakes. Phys. of Earth & Planet. Interiors 151, 243-258.

List of Papers related to Chapter 12 (Heavy Ion Radiation Damage Track Studies in SSNTDs)

1. Virk H S (1981) Anomalous effects of temperature on fission fragment tracks in soda glass. Int. J. of Appl. Rad. and Isotopes, 32, 933.
2. Modgil S K and Virk H S (1982) Efficiency calibration and effect of etchant temperature on fission fragment tracks in soda glass detector. Int. J. Appl. Rad. and Isotopes, 33, 495-497.
3. Modgil S K and Virk H S (1982) Thermal stability of fission tracks in sodalime microslide glass. Int. J. Appl. Rad. and Isotopes, 33, 779-780.
4. Singh T, Singh M and Virk H S (1982) A new track etchant for plastic detectors. Nucl. Tracks, 6, 197-199.
5. Modgil S K and Virk H S (1983) Inter-laboratory standardization of glass dosimeters. Nucl. Instrum. and Meth., 212, 367-370.
6. Modgil S K and Virk H S (1983) Effect of etchant parameters on track development in soda-lime glass detector. Proc. 3rd National Conf. on SSNTDs, GNDU, Amritsar pp.59-67.
7. Singh M, Singh N P, Singh S and Virk H S (1983) Track recording by sensitization in plastics. Proc. 3rd National Conf. on SSNTDs, GNDU, Amritsar, pp.24-27.
8. Modgil S K and Virk H S (1984) Effect of etchant concentration and temperature on bulk etch rate for solid state track detectors. Nucl. Tracks and Rad. Meas., 8, 95-98.
9. Modgil S K and Virk H S (1984) Track annealing studies in glasses and minerals. Nucl. Tracks and Rad. Meas., 8, 355-360.
10. Modgil S K and Virk H S (1985) Annealing of fission fragment tracks in inorganic solids. Nucl. Instrum. and Methods in Phys. Res. B, 12, 212-218.
11. Singh G, Devi S, Singh S and Virk H S (1986) Track etch rate characteristics of Makrofol polycarbonate plastic detectors exposed to Xe ions. Nucl. Tracks and Rad. Meas., 12, 383-386.
12. Virk H S, Modgil S K and Bhatia R K (1986) Activation energy for the annealing of radiation damage in CR-39 : An intrinsic property of detector. Nucl. Tracks and Radiat. Meas., 11, 323-325.
13. Virk H S, Modgil S K and Singh G (1987) Fission track annealing models and the concept of single activation energy. Nucl. Instrum. and

- Meth. in Phys. Res. B, 21, 68-71.
14. Singh R C and Virk H S (1987) Internal heating effect during electrochemical etching of lexan polycarbonate. Nucl. Instrum. and Meth. in Phys. Res. B, 29, 579-582.
 15. Singh R C and Virk H S (1987) Relation between internal heating effect and track density during electrochemical etching of Lexan polycarbonate. Ind. J. Pure and Appl. Phys., 25, 237-238.
 16. Bhatia R K and Virk H S (1987) Annealing study of heavy ion tracks in CR-39. Ind. J. Pure and Appl. Phys., 25, 282-283.
 17. Singh G, Modgil S K and Virk H S (1987) Annealing of heavy ion tracks in soda-lime glass detector. Nucl. Tracks: Proc. 5th National SSNTD Conf., SINP, Calcutta, p. 89-93.
 18. Sandhu A S, Singh S and Virk H S (1987) Fission track annealing in apatite. Nucl. Tracks: Proc 5th National SSNTD Conf., SINP, Calcutta, p.94-98.
 19. Virk H S (1987) Track annealing models and concept of single activation energy. Nucl. Tracks: Proc. 5th National SSNTD Conf., SINP, Calcutta, p. 200-206.
 20. Singh G and Virk H S (1987) Track annealing studies in soda-lime glass detector. GSI Scientific Report (Darmstadt) p.240.
 21. Bhatia R K, Sandhu A S and Virk H S (1987) Etch rate variation of annealed nuclear tracks in CR-39. GSI Scientific Report (Darmstadt) p.241.
 22. Sandhu A S, Bhatia R K, Singh S and Virk H S (1987) Track annealing studies in muscovite mica. GSI Scientific Report (Darmstadt) p.242.
 23. Sandhu A S, Singh S and Virk H S (1988) Anisotropic etching and annealing studies of fission tracks in quartz. Mineral. Journ. of Japan, 14, 1-11.
 24. Singh J, Singh S and Virk H S (1988) Etching studies of CR-39 plastic track recorder. Nucl. Track and Rad. Meas., 15, 187-190.
 25. Sandhu A S, Singh S and Virk H S (1988) Activation energy of track annealing in minerals as a function of inter-atomic spacing. Nucl. Track and Rad. Meas., 15, 235-238.
 26. Bhatia R K and Virk H S (1988) Annealing kinetics of heavy ion tracks in CR-39. Nucl. Track and Rad. Meas., 15, 239-240.
 27. Sandhu A S, Singh S and Virk H S (1988) Track annealing studies in muscovite mica. Nucl. Track and Rad. Meas., 15, 241-244.
 28. Sandhu A S, Singh S and Virk H S (1988) Anisotropic etching and annealing studies of fission tracks in zircon. Nucl. Track and Rad. Meas., 15, 245-247.

29. Bhatia R K and Virk H S (1988) Post irradiation annealing in plastic detector CR-39. Nucl. Track and Rad. Meas., 15, 249-251.
30. Singh G and Virk H S (1988) Annealing of heavy ion radiation damage in soda-glass detector. Nucl. Track and Rad. Meas., 15, 253-256.
31. Singh R C and Virk H S (1988) Electrochemical etching of fission fragment tracks in cellulose triacetate. Nucl. Track and Rad. Meas., 15, 301-303.
32. Singh S, Singh H, Singh N P and Virk H S (1988) Applications of plastic track detectors in thermal neutron dosimetry and boron estimation in plants. Nucl. Track and Rad. Meas., 15, 507-510.
33. Virk H S, Modgil S K, Singh G and Bhatia R K (1988) Annealing characteristics of heavy ion radiation damage in SSNTDs and concept of single activation energy. Nucl. Instr. Meth. Phys. Res. B32, 401-404.
34. Singh R C, Bhatia R K and Virk H S (1988) Annealing study of heavy ion tracks in Makrofol- N using electrochemical etching technique. Ind. J. Pure and Appl. Phys., 26, 673-674.
35. Bhatia R K and Virk H S (1988) Etching studies of radiation damage in CR-39. Ind. J. Pure and Appl. Phys., 26, 428-430.
36. Singh R C and Virk H S (1988) Electrochemical etching of fission fragment tracks in muscovite mica and soda glass. Nucl. Instrum. and Meth. in Phys. Res. B, 30, 598-600.
37. Sandhu A S, Bhatia R K, Ramola R C, Singh S and Virk H S (1988) Thermal annealing of nuclear tracks in minerals. GSI Scientific Report (Darmstadt) p.244.
38. Bhatia R K, Sandhu A S, Singh R C and Virk H S (1988) Annealing studies in plastic track detectors. GSI Scientific Report (Darmstadt) p.245.
39. Sandhu A S, Ramola R C, Singh S and Virk H S (1989) Annealing of heavy ion radiation damage in muscovite mica and concept of single activation energy. Radiat. Eff., 107, 75-78.
40. Bhatia R K and Virk H S (1989) Heavy ion radiation damage annealing models-A new interpretation. Radiat. Eff., 107, 167-173.
41. Sandhu A S, Singh L, Ramola R C, Singh S and Virk H S (1989) Etching studies of radiation damage in natural zircon. Indian J. Pure and Appl. Phys., 27, 237-239.
42. Singh R C, Bhatia R K and Virk H S (1989) Preparation and application of microfilters. Ind. J. Pure and Appl. Phys., 27, 285-286.
43. Bhatia R K and Virk H S (1989) Influence of etching conditions on the efficiency and critical angle of plastic detector Makrofol-N. Ind. J. Pure and Appl. Phys., 27, 249-250.

44. Singh R C and Virk H S (1989) Effect of variation of incident angle of alpha particles at various field strengths on ECE response of CR 39. Nucl. Instrum. Meth. Res. B, 36, 332-334.
45. Singh G and Virk H S (1989) Activation energy for the annealing of heavy ion radiation damage in a soda-glass detector. Nucl. Tracks Radiat. Meas., 16, 279-281.
46. Singh L, Sandhu A S, Singh S and Virk H S (1989) Thermal annealing of heavy ion tracks in muscovite mica. Radiat. Eff., 108, 257-266.
47. Singh G and Virk H S (1989) Heavy ion radiation damage annealing in glass detectors. Nucl. Instrum. Meth. Phys. Res. B, 44, 103-106.
48. Sandhu A S, Singh L, Ramola R C, Singh S and Virk H S (1990) Annealing kinetics of heavy ion radiation damage in crystalline minerals. Nucl. Instrum. Meth. Phys. Res. B, 46, 122-124.
49. Singh L, Sandhu A S, Singh S and Virk H S (1990) Etching and annealing kinetics of heavy ion tracks in quartz. Nucl. Instrum. Meth. Phys. Res. B, 46, 149-151.
50. Bhatia R K, Singh R C and Virk H S (1990) Anomalous behaviour of environment affected CR-39 at elevated temperatures. Nucl. Instrum. Meth. Phys. Res. B, 46, 358-360.
51. Sandhu A S, Singh S and Virk H S (1990) Effect of nature of the etchant on anisotropic track etching in quartz. Ind. J. Pure and Appl. Phys., 28, 73-75.
52. Sandhu A S, Ramola R C, Singh S and Virk H S (1990) Fission track annealing in minerals. Nucl. Tracks Radiat. Meas., 17, 267-269.
53. Sandhu A S, Ramola R C, Singh S and Virk H S (1990) Etching and annealing characteristics of fission tracks in garnet. Indian J. of Pure and Appl. Phys., 28, 522-524.
54. Singh G and Virk H S (1990) Radiation damage annealing models in glass detectors. Radiat. Eff. and Def. in Solids, 114, 51-52.
55. Singh G and Virk H S (1990) Thermal effects of heavy ion radiation damage in glass track detectors. Radiat. Eff. and Def. in Solids, 114, 219-224.
56. Virk H S (1990) Heavy ion ranges in plastic track detectors. GSI Scientific Report (Darmstadt), p.256.
57. Virk H S (1991) Single activation energy model of radiation damage in solid state nuclear track detectors. Curr. Sci., 61, 386-390.
58. Singh S, Singh L, Singh J, and Virk H S (1991) Heavy ion radiation damage annealing in garnet crystal. Nucl. Tracks and Radiat. Meas., 19, 121-126.
59. Singh G, Kaur R, and Virk H S (1991) Track etching studies in phosphate glass detectors. Nucl. Tracks and Radiat. Meas., 19, 655-656.

60. Virk H S (1991) Status and perspectives of track research at Guru Nanak Dev University, Amritsar. Nucl. Tracks and Radiat. Meas., 19, 861-867.
61. Singh G and Virk H S (1991) Track annealing studies in glass detectors using optical absorption spectroscopy. GSI Scientific Report (Darmstadt), GSI 92-1, p.262.
62. Singh R C and Virk H S (1991) Role of polarization and tensile strength in the process of electrochemical etching (ECE). Nucl. Tracks and Radiat. Meas., 18, 419-421.
63. Virk H S (1992) Heavy ion radiation damage annealing in track recording insulators and single activation energy model. Nucl. Instrum. and Meth. Phys. Res. B, 65, 456-458.
64. Virk H S, Bedi M and Singh L (1992) Aspect ratio of heavy ion tracks in mica and CR-39 plastic. GSI Scientific Report (Darmstadt), GSI 93-1, p. 287.
65. Singh G, Kaur R and Virk H S (1992) Etching characteristics in phosphate glass detectors. GSI Scientific Report (Darmstadt), GSI 93-1, p. 293.
66. Virk H S, Kaur R and Singh G (1993) Heavy ion ranges in glass detectors. Nucl. Tracks & Radiat. Meas., 22, 245-248.
67. Virk H S (1993) Heavy ion ranges in plastic track detectors. Nucl. Tracks & Radiat. Meas., 22, 243-244.
68. Singh L, Singh J, Singh S and Virk H S (1993) Recovery stages of heavy ion produced defects in quartz crystal. Nucl. Tracks & Radiat. Meas., 22, 229-232.
69. Singh G and Virk H S (1993) Etching and annealing behaviour of nuclear tracks in glass detectors. Proc. of Eighth National Conference on Solid State Nuclear Track Detectors (SSNTD), A.M.U. Aligarh, Oct.27-29,1993, pp.89-94.
70. Virk H S and Singh R C (1994) Alternative approach to fast neutron dosimetry. Ind. J. of Pure and Appl. Phys., 32, 526-527.
71. Virk H S and Bedi Mona (1994) Aspect ratio of heavy ion tracks in mica and CR-39 plastic. Ind. J. of Pure and Appl. Phys., 32, 364-367.
72. Singh G and Virk H S (1994) Annealing characteristics of nuclear tracks in glass detectors using optical absorption spectroscopy. J. Radioanal. and Nucl. Chem., 180, 139 - 144.
73. Randhawa G S, Garg A K, Singh G and Virk H S (1994) Heavy ion ranges in soda-glass detector. Ind. J. Pure and Appl. Phys., 32, 846-848.
74. Virk H S (1995) Single activation energy model of radiation damage in SSNTDs. Radiat. Eff. and Def. in Solids, 133, 87-95.

75. Randhawa G S, Garg A K and Virk H S (1995) Ranges study of heavy ions in plastic track detectors. *Radiat. Meas.* 24, 197-199.
76. Randhawa G S and Virk H S (1995) Particle identification by measurement of track cone length as function of residual range of heavy ions in CR-39 and Lexan polycarbonate. *Appl. Radiat. & Isotopes* 46, 351-353.
77. Randhawa G S and Virk H S (1995) Track etching characteristics of glass track detectors. *Appl. Radiat. & Isotopes* 47, 351-354.
78. Virk H S and Kaur S Amrita (1995) Conduction of bacteria and blood cells through polycarbonate sieves. *Ind. J. Pure Appl. Phys.*, 33, 350-352.
79. Randhawa G S, Sharma S K and Virk H S (1996) Inter-comparison of experimental and theoretical range values in plastic detectors. *Nucl. Instrum. Meth. Phys. Res. B*, 108,7-10.
80. Virk H S and Randhawa G S (1996) Aspect ratio of heavy ion tracks in different track recording dielectrics. *Proc. of Ninth Int. Conf. on Ion Beam Modification of Materials*, Canberra, Australia, 5-10 Feb., 1995, pp. 694-697.
81. Randhawa G S and Virk H S (1996) Stopping power and range of heavy ions in solids: A comparative study. *Radiat. Meas.* 26, 541-560.
82. Virk H S and Randhawa G S (1997) Stopping power and range relations for low and high Z ions in solids: A critical analysis. *Proc. 3rd Int. Conf. on Material Science Applications of Ion Beam Techniques* held at Seeheim, Germany, 9-12 Sept. *Material Sci. Forum* (Trans. Tech. Publications), pp. 33-40.
83. Kaur Amrita S, Virk H S and Chkravarti S K (1997) Application of ion track filters: Our experience *Proc. 3rd Int. Conf. on Material Science applications of Ion Beam Techniques* held at Seeheim, Germany, 9-12 September. *Material Sci. Forum* (Trans. Tech. Publications), pp. 467-470.
84. Randhawa G S, Kumar Shyam and Virk H S (1997) Response of different plastic track detectors to α -particle. *Radiat. Meas.* 27, 523-527.
85. Randhawa G S and Virk H S (1997) Thermal annealing of latent tracks in soda and BP-1 phosphate glasses. *Appl. Radiat. and Isotopes*, 48, 447-451.
86. Randhawa G S and Virk H S (1997) Identification of charged particles by etching the solid state nuclear track detectors in successive intervals. *Ind. J. Pure and Appl. Phys.*, 35, 479-482.
87. Jain R K, Virk H S, Rao J Rama and Bose S K (1997) Measurement of fast neutron induced fission cross section of Thorium using Lexan track detector. *Pramana*, 49 (5), 515-519.

88. Randhawa G S and Virk H S (1997) Study of charged particle tracks in barium phosphate (BP-1) glass. Nucl. Instrum. and Meth., B132 (1997) 653-659.
89. Jain R K, Randhawa G S, Bose S K and Virk H S (1997) Study of etching and annealing characteristics of ^{238}U ion tracks in Trifol-TN polycarbonate. J. Phys D: Appl. Phys., 31, 328-333.
90. Jain R K, Randhawa G S, Bose S K and Virk H S (1998) Etching and annealing kinetics of ^{238}U ion tracks in Makrofol-N plastic. Nucl. Instrum. Meth., 140, 367-372.
91. Virk H S and Kaur S Amrita (1998) Single pore sensor for water pollution control. Environment and Development (Eds. I.S. Grover and A.K. Thukral), Scientific Publishers, Jodhpur, India, pp.217-221.
92. Virk H S, Kaur S Amrita and Randhawa G S (1998) Effects on insulators of swift-heavy-ions radiation: Ion track technology. J. of Phys. D: App. Phys., 31, 3139-3145.
93. Virk H S and Kaur Amrita S. (1998) Ion Track Filters: Properties, Development and Applications. Curr. Sci., 75 (8), 765-770.
94. Virk H S, Randhawa G S, Kaul A D and Wadhwa SS (1999) Atomic force microscopy of heavy ion latent tracks in some track recording materials. Proc. XI National Symposium on SSNTDs, GND University, Amritsar, Oct.12-14, 1998, pp. 182-188.
95. Singh R C, Sandhu A S and Virk H S (1999) Significance of dielectric properties for electrochemical etching response of a nuclear track detector. Proc. XI National Symposium on SSNTDs, GND University, Amritsar, Oct. 12-14, 1998, pp. 153-155.
96. Virk H S and Randhawa G S (1999) Heavy ion radiation effects in insulators and their atomic force microscopy. Proc. National Conf. on Characterization of Semiconductor Materials (Ed. R.K.Bedi), GND University, Amritsar, pp. 237-248.
97. Srivastava A K and Virk H S (1999) Spectral response of some polymers to 14 MeV neutron irradiation. Ind. J. Pure and Appl. Phys., 37, 713-717.
98. Virk H S, Randhawa G S, Thangraj R, Asokan K and Avasthi D K (1999) $^{12}\text{C}^{5+}$ radiation effects in SR-86 track recording polymer. Bull. of Material Sci., 22, 791-795.
99. Virk H S, Randhawa G S and Thangraj R (1999) $^{12}\text{C}^{5+}$ radiation effects in some polymers. Nucl. Instrum. Meth. Phys. Res. B., 152, 500-505.
100. Kaur S Amrita, Randhawa G S, Chakarvarti S K and Virk H S (1999) Fabrication of metallic and polymeric microstructures using ion track filters. Ind. J. Pure and Appl. Phys., 37, 924-928.
101. Virk H S and Srivastava A K (1999) Ion beam modification of

- polymeric materials using accelerators. Proc. Thirteenth National Conf. on Radiation Physics, Mangalore University, Mangalagangothri, Dec. 21-23, 1999, pp. 423-428.
102. Randhawa G S and Virk H S (2000) Heavy ion range measurements in some glasses using back track etching technique. *Rad. Meas.*, 32, 283-287.
103. Srivastava A K and Virk H S (2000) Study of electrical and optical frequency response of neutron irradiated polyvinyl acetate thick films. *Rad. Phys. & Chem.*, 59, 31-37.
104. Srivastava A K and Virk H S (2000) Modification of optical response of Polyvinyl Acetate induced by 250 keV D⁺ ion bombardment. *J. Poly. Materials*, 17, 325-328.
105. Virk H S, Srivastava A K, Thangraj R, Asokan K and Avasthi D K (2000) Swift heavy ion beam induced modifications in polymers. Annual Report (1999-2000), Nuclear Science Centre, New Delhi, pp. 105-106.
106. Virk H S and Srivastava A K (2000) Modification of the optical, chemical and structural properties of 50 MeV ⁷Li³⁺ ion bombarded polyimide Kapton – H. *Ind. J. Pure & App. Physics*, 38, 570-573.
107. Srivastava A K and Virk H S (2000) 50 MeV Lithium ion beam irradiation effects in Polyvinylidene fluoride (PVDF). *Bull. Mat. Sci.*, 23(6), 533-538.
108. Virk H S and Srivastava A K (2001) Modification of optical, chemical and structural response of CR-39 polymer by 50 MeV Lithium ion irradiation. *Rad. Meas.*, 34, 65-67.
109. Virk H S, Kaur S.A. and Randhawa G.S. (2001) Role of ion track filters in environmental surveillance. *Environment International*, 27, 359-362.
110. Virk H S, Chandi P S and Srivastava A K (2001) Optical and chemical response of 50 MeV lithium ion irradiated poly (vinylidene fluoride) polymer. *Jour. Polym. Materials*, 18(4), 393-398.
111. Virk H S, Chandi P S and Srivastava A K (2001) Electrical and optical response of Lithium ion irradiated Polyimide (Kapton). *Rad. Eff. & Defects Solids*, 153, 325-334.
112. Virk H S, Chandi, P S and Srivastava A K (2001) Physical and chemical response of 70 MeV Carbon ion irradiated Kapton-H polymer. *Bull. of Mat. Sci.*, 24, 529-534.
113. Virk H S, Chandi, P S and Srivastava A K (2001) Physical and chemical changes induced by 70 MeV C-ions in poly vinylidene fluoride (PVDF) polymer. *Nucl. Instrum. Meth. Phys. Res. B*, 183, 329-336.
114. Virk H S (2002) Physical and chemical response of 70 MeV carbon ion irradiated Kapton-H polymer. *Proc. 11th Int. Conf. on Radiation Effects*

- in Insulators, Lisbon, Sept.3-7, 2001. Nucl.Instrum.Meth.Phys. Res. B, 191, 739-743.
115. Virk H S, Chandi P S and Varada Rajulu A (2004) Physical and chemical changes induced by 70 MeV Carbon Ions in Polymethyl Methacrylate (PMMA). Proc. Int. Conference on Computer Simulation and Material Technologies (MMT-2004), College of Judea and Samaria, Ariel, Israel, pp. 89-95.
116. Virk H S (2004) Heavy ion tracks in solids: A quantum jump to Nanotechnology. Proc. Int. Conference on Computer Simulation and Material Technologies (MMT-2004), College of Judea and Samaria, Ariel, Israel, pp. 96-99.
117. Kumar R, Ali S A, Mahur A K, Das D, Naqvi, A H, Virk H S and Prasad R (2006). Free volume study of 70 MeV carbon induced modification in polymers through positron annihilation. Nucl. Instrum. Meth. Phys. Res. B, 244, 257-260.
118. Kumar R, Virk H S, Verma K C, De U and Prasad R (2006). Physico-Chemical Modifications Induced in Makrofol-N Polycarbonate by Swift Heavy Ions. Nucl. Instrum. Meth. Phys. Res. B, 251, 163-166.
119. Kumar R, Ali S A, Mahur A K, Virk H S, Singh F, Khan S A, Avasthi D K and Prasad R (2008). Study of Optical Band Gap and Carbonaceous Clusters in Swift Heavy Ion Irradiated Polymers with UV-Vis Spectroscopy. Nucl. Instrum. Meth. Phys. Res. B 266, 1788-1792.
120. Kumar R, Ali S, Naqvi A H, Virk H S, De U, Avasthi D K and Prasad R (2009). Study of optical band gap and carbon cluster sizes formed in 100 MeV Si^{8+} and 145 MeV Ne^{6+} ion irradiated Polypropylene Polymer. Ind. J. of Physics 83(7), 969-976.
121. Ravi Chand Singh, Manwinder Singh and Virk H S (2009) Electrochemical etching technique for neutron dosimetry. Ind. J. of Physics 83(6), 827-832.
122. Kumar R, Singh P, Virk H S and Prasad R (2010) 70 MeV Carbon C^{5+} ion induced modifications in polyethylene terephthalate polymer. Indian J. Pure & Appl. Phys. 48, 16-19.
123. Singh P, Kumar R, Virk H S and Prasad R (2010) Modification of optical, chemical and structural response of polymethyl methacrylate polymer by 70 MeV carbon ion irradiation. Ind. J. Pure & Appl. Phys. 48, 321-325.
124. Rajesh Kumar, S.A. Ali, Paramjit Singh, U. De, H.S. Virk and R. Prasad (2011) Physical and chemical response of 145 MeV Ne^{6+} ion irradiated polymethyl-methacrylate (PMMA) polymer. Nucl. Instrum. and Meth. Phys. Res. B 269, 1755-1759.
125. Virk H.S. (2015) Modgil-Virk Formulation of Single Activation Energy

Model of Radiation Damage Annealing in SSNTDs: A Critical Appraisal. In: Radiation Induced Modification of Materials (Ed. H.S. Virk), Solid State Phenomena Series, Trans Tech Publications, Switzerland, Vol.239, pp. 215-242.

List of Papers related to Chapter 13 (Nanotechnology)

1. Virk H S (2009) Heavy Ion Track Route to Nanotechnology. *Advanced Materials Research*, 67, 115-120.
2. Poonam Sharma and Virk H S (2009) Fabrication of nanoparticles of Barium carbonate/ oxalate using Reverse Micelle technique. *The Open Surface Science Journal* 1, 23-28.
3. Virk H S, Baloria V and Poonam Sharma (2009) An Overview of Nanotechnology Research at DAV Institute of Engineering & Technology (DAVIET), Jalandhar, India. *Ind. Sci. Cruiser*, 23(4), 29-34.
4. Virk H S, Kishore K and Baloria V (2010) Fabrication of Copper Nanowires by Electrodeposition using Anodic Alumina and Polymer Templates. *J. of Nano Research* 10, 63-67.
5. Virk H S and Poonam Sharma (2010) Heavy ion irradiation effects on Cadmium oxide (CdO) quantum dots prepared by quenching method. *J. of Nano Research* 10, 69-76.
6. Virk H S and Poonam Sharma (2010) Fabrication of Nanoparticles and Nanowires using Reverse Micelle and Template Synthesis techniques. *Tata McGraw Hill Professional Publication*, pp. 37-41.
7. Virk H S (2010) Template synthesis of Cu-Se hetero-junctions using anodic alumina membrane and their characterization. *Digest J. of Nanomater. & Nanostructures*, 5(3), 593-598.
8. Virk H S (2010) Quantum dots and Nanowires: Fabrication and characterization. *International Journal of Advanced Engineering Technology* 1(2), 55-60.
9. Virk H.S. and Poonam Sharma (2010) Chemical route to Nanotechnology. *International Journal of Advanced Engineering Technology*, 1(3), 114-129.
10. Virk H.S and Poonam Sharma (2010) Synthesis, Characterization and Clustering Phenomenon of Zinc Oxide Nanocrystals. *Int. J. of Nanosci. & Tech.* 1(1), 11-16.
11. Virk H.S. (2010) Fabrication of polycrystalline copper nanowires by electrodeposition in anodic alumina membrane and their characterization. *Nano Trends*, 9(1), 1-9.
12. Poonam Sharma and Virk H S (2010) Effect of co-surfactant and water to surfactant molar ratio on the CdS nanoparticles in microemulsion.

- Nano Trends 9(3), 1-12.
13. Virk H S, Poonam Sharma and Rajshree Jotania (2011) Comparative study of Ba-M hexaferrite particles prepared using microemulsion processing and co- precipitation techniques. *International Journal of Advanced Engineering Technology*, 2(1), 131-143.
 14. Virk H. S. (2011) Fabrication and Characterization of Copper Nanowires: An Overview. *Journal of NanoScience, Nano Engineering& Applications*, 1(1), 1-16.
 15. Jotania R, Poonam Sharma and Virk H S (2011) Effect of CTAB surfactant on the microstructural and magnetic properties of Barium hexaferrite. *J. Nanoscience Letters*, 1(1), 63-71.
 16. Virk H.S. (2011) Template synthesis and morphology of CdS nanowire arrays using anodic alumina membranes. *Nano Trends* 10 (2), 17-24.
 17. Virk H S (2011) Template growth of copper nanowires and exotic patterns of metallic copper using electrodeposition technique. *International Journal of Advanced Engineering Technology*, 2(3), 64-68.
 18. Virk HS (2011) Effects of 90 MeV Carbon ion irradiation on Cadmium oxide quantum dots. *Current Science* 100(10), 1540-1542.
 19. Virk H S (2011) Fabrication and characterization of metallic Copper and Copper Oxide nanoflowers. *Pakistan J. of Chemistry* 1(4), 1-7.
 20. Virk H.S. (2011) Fabrication and Characterization of Copper Nanowires. Chapter 20 of Book “Nanowires - Implementations and Applications”, Abbass Hashim (Ed.), ISBN: 978-953-307-318-7, In Tech, Available from: <http://www.intechopen.com/articles/show>
 21. Rajshree B Jotania and Hardev Singh Virk (2012) Y-type hexaferrites: Structural, Dielectric and Magnetic properties. In: *Ferroics and Multiferroics* (Eds. H.S.Virk & W. Kleemann), Trans Tech Publications, Switzerland, pp. 209-232.
 22. Virk H.S. (2012) Synthesis of metallic Copper nanoflowers, nanocrystals and nanorods using electrodeposition and hydrothermal techniques. *J. of NanoScience, NanoEngg. & Applications*, 2 (1), 23-37.
 23. Virk H.S. (2013) Our Fabrication Routes to Nanotechnology. In: *Solid State Nuclear Track Detectors and their Applications* (Ed. N. L. Singh), Proc. of 17th National SSNTD Conference held in MSU Baroda, Vadodra, Oct. 25-27, 2011. Narosa Publishing House, New Delhi, pp. 109-114.
 24. Virk H.S. (2013) Synthesis and Characterization of Metal and Semiconductor Nanowires. In: *Functional Nanomaterials and their Applications* (Ed. Hardev Singh Virk), Solid State Phenomena Series, Trans Tech Publications, Switzerland, pp. 21-64.

25. Ravi Chand Singh, Manmeet Pal Singh and Hardev Singh Virk (2013) Applications of Nanostructured Materials as Gas Sensors. In: Functional Nanomaterials and their applications (Ed. Hardev Singh Virk), Solid State Phenomena Series, Trans Tech Publications, Switzerland, pp. 131-158.
26. Virk H.S. (2013) Fabrication of Nanoflowers and Other Exotic Patterns. In: Functional Nanomaterials and their Applications. (Ed. Hardev Singh Virk), Solid State Phenomena Series, Trans Tech Publications, Switzerland, pp.159-180.
27. Murthy KVR and Virk H.S. (2013) Luminescence Phenomena: An Introduction. In: Luminescence Related Phenomena and their Applications. (Ed. Hardev Singh Virk), Defect and Diffusion Forum Series, Trans Tech Publications, Switzerland, pp.1-34.
28. Omanwar SK, Koparkar KA and Virk HS (2013) Recent Advances and Opportunities in TLD Materials: A Review. In: Luminescence Related Phenomena and their Applications. (Ed. Hardev Singh Virk), Defect and Diffusion Forum Series, Trans Tech Publications, Switzerland, pp.75-110.
29. Hardev Singh Virk (2014) History of Luminescence from Ancient to Modern Times. In: Luminescent Materials and their Applications. (Ed. Hardev Singh Virk), Defect and Diffusion Forum Series, Trans Tech Publications, Switzerland, Vol. 361, pp. 1-13.
30. P.K. Bajpai, S. Yadav, A. Tiwari and H.S. Virk (2015) Recent Advances in the Synthesis and Characterization of Chalcogenide Nanoparticles. In: Nanomaterials: Basic Concepts and Applications. (Ed. Hardev Singh Virk), Solid State Phenomena Series, Trans Tech Publications, Switzerland, pp. 187-233.
31. K. Praveena, K. Sadhana and H.S. Virk (2015) Structural and Magnetic Properties of Mn-Zn Ferrites Synthesized by Microwave-Hydrothermal Process. In: Ferroic Materials: Synthesis and Applications (Ed. Hardev Singh Virk), Solid State Phenomena Series, Trans Tech Publications, Switzerland, pp. 45-64.
32. P.K. Dewan and H.S. Virk (2015) Heavy Ion Range Measurements in SSNTD Materials: A Review. In: Solid State Nuclear Track Detectors and their Applications (Ed. Hardev Singh Virk), Solid State Phenomena Series, Trans Tech Publications, Switzerland, Vol. 238, pp. 174-195.
33. B. Rani, K. Sharma, Neetu, Anupam, S. Kumar and H.S. Virk (2015) Energy Loss for Swift Heavy Ions in Different Elemental Absorbers: A Different Approach for Effective Charge Parameterization. In: Solid State Nuclear Track Detectors and their Applications (Ed. Hardev Singh Virk), Solid State Phenomena Series, Trans Tech Publications,

- Switzerland, Vol. 238, pp. 196-205.
34. D. Singh, G. S. Mudahar, K. S. Thind and H. S. Virk (2015) Structural Investigations of Gamma-irradiated PbO Glasses. In: Radiation Induced Modification of Materials (Ed. Hardev Singh Virk), Solid State Phenomena Series, Trans Tech Publications, Switzerland, Vol.239, pp. 98-109.
 35. Divya Singh, B. Bhattacharya and H.S. Virk (2015) Conductivity Modulation in Polymer Electrolytes and their Composites due to Ion-Beam Irradiation. In: Radiation Induced Modification of Materials (Ed. Hardev Singh Virk), Solid State Phenomena Series, Trans Tech Publications, Switzerland, Vol.239, pp. 110-148.
 36. L. Sajó-Bohus, H. R. Vega-Carrillo and H.S. Virk (2015) SSNTD Technique in Photo-Neutron Applications. In: Radiation Induced Modification of Materials (Ed. Hardev Singh Virk), Solid State Phenomena Series, Trans Tech Publications, Switzerland, Vol.239, pp.180-214.
 37. J.K. Sharma, Pratibha Srivastava, Gurdip Singh and H.S. Virk (2016) Nanoferrites of Transition Metals and Their Catalytic Activity. In: Ferrites and Ceramics II (Ed. Rajshree Jotania & Hardev Singh Virk), Solid State Phenomena Series, Trans Tech Publications, Switzerland, Vol. 241, pp. 126-138.
 38. N. Varalaxmi, K.V. Sivakumar and H.S. Virk (2016) Studies on Internal Friction and Curie-Temperature of NiMgCuZn Spinel Ferrites for Micro-Inductor Applications. In: Ferrites and Ceramics II (Ed. R. Jotania & H. S. Virk), Solid State Phenomena Series, Trans Tech Publications, Switzerland, Vol. 241, pp. 202-225.

List of Papers related to Chapter 14 (History & Philosophy of Science and Other Areas)

1. Virk H S (1986) Ibn Sina's approach to Physics. Ind. J. History of Sci., 21, 374-378.
2. Virk H S (1987) Reality: Physical, Metaphysical and Mystical. History and Philosophy of Science (Ed. H.S.Virk) :Proc. First National Seminar, GND University, Amritsar, pp. 79-90.
3. Virk H S (1992) Abdus Salam: A grand unifier of men and forces. Abdus Salam: As We Know Him (Ed. S.M.W. Ahmed), World Scientific, Singapore, pp. 79-85.
4. Virk H S (1993) Life and works of Puran Singh. Ind. J. Hist. of Science, 28, 277-285.
5. Virk H S (1997) A genius called Abdus Salam: An obituary. Curr. Sci., 72, 892-894.

6. Virk H S (1998) Prof. Puran Singh (1881-1931): Founder of Chemistry of forest products in India. *Curr. Sci.*, 74, 1023-1024.
7. Virk H S (1998) Prof. Bawa Kartar Singh: A pioneer in Stereochemistry in India. *Curr. Sci.*, 75(7), 738- 739.
8. Virk H S (2002) Professor Piara Singh Gill: A pioneer cosmic ray physicist of India. *Curr. Sci.*, 82 (11), 1404-1405.
9. H.S. Virk (2015) Nature of Reality: Physical, Metaphysical and Mystical Aspects. *Omniscience*, 5(2), 10-15.
10. H.S. Virk (2015) Nature of Reality in Science and Sikh Religion, Chapter 19, pp. 350-367, in: *Mastery Meets Mystery: Intersecting Science, Philosophy, Religion and Culture*, (Ed.) Augustine Pamplany, Serials Publications Pvt. Ltd., New Delhi.
11. H.S. Virk (2016) Classical Physics versus Quantum Physics: An Overview. *Omniscience* 4(2), 1-7.
12. H.S. Virk (2016) Enigmas (Puzzles) in Teaching and Learning of Physics. *Omniscience*, 5(3), 18-21.
13. H.S. Virk (2016) Tracing the Roots of Dual Nature of Matter and Radiation in Science and Religion. *Omniscience*, 6(1), 1-7.
14. H.S. Virk (2016) Probing India's Failure to Produce Nobel Laureates in Science after CV Raman. *Omniscience*, 6(2), 8-11.
15. H.S. Virk and Rajinder Singh (2016) The Pioneers of Cosmic Ray Research in India. *Research and Reviews: J. of Space Science & Technology*, 5(2), 17-23.
16. H.S. Virk, R. Jakhu and P. Bangotra (2016) Natural Uranium Content in Ground Waters of Mohali and Fatehgarh Districts of North Punjab (India) for the Assessment of Excess Cancer Risk. *Global J. of Human-Social Science*, 16(4), 12-17.
17. H.S. Virk (2016) Punjab in the Grip of an Ecological Disaster: Is there a Solution? *Global J. of Human-Social Science*, 16(4), 1-2.
18. H.S. Virk (2016) Up Against Odds: The Story of an Indian Researcher. *Omniscience*, 6(3), 1-4.
19. H.S. Virk (2016) Measurement of Concentration of Natural Uranium in Ground Waters of Bathinda District (S. Punjab) for the Assessment of Annual Effective Dose. *Global J. of Human-Social Science*, 16(5), 25-29.
20. H.S. Virk (2016) Nuclear Track Studies in India: A Historical Review. *J. of Nucl. Engg. & Tech.* 6(3), 1-7.
21. H.S. Virk (2016) Book Review: Inside Story of Nobel Peace Prize Award - Indian Contestants. *Science and Culture*, 82(7-8) 267-268.
22. Hardev Singh Virk (2017) Uranium Anomalies in groundwater of Sangrur district of Punjab (India) for cancer risk assessment. *Current*

- Science 113(9), 1661-1663.
23. H. S. Virk (2017) A Crisis Situation Due to Uranium and Heavy Metal Contamination of Ground Waters in Punjab State, India: A Preliminary Report. *Research & Reviews: A Journal of Toxicology* 7(2), 6-11.
 24. Hardev Singh Virk (2017) Uranium Content Anomalies in Groundwaters of Fazilka District of Punjab (India) for the Assessment of Excess Cancer Risk. *Research & Reviews: Journal of Oncology and Hematology* 6(2), 21-26.
 25. Hardev Singh Virk (2017) Punjab in the grip of an ecological disaster: is there a solution? *Science and Culture*, 83(11-12), 390-391.
 26. Hardev Singh Virk (2017) Response to Comments on "Uranium Content Anomalies in Groundwaters of Fazilka District of Punjab (India) for the Assessment of Excess Cancer Risk". *Research & Reviews: Journal of Oncology and Hematology* 6(3), p. 2.
 27. Hardev Singh Virk (2017) A Preliminary Report on Groundwater Contamination of Majha Belt of Punjab due to Heavy Metal Arsenic. *Research & Reviews: A Journal of Toxicology* 7(3), 27-33.
 28. Rajinder Singh and Hardev Singh Virk (2017) Homi J. Bhabha: Physics Nobel Prize Nominee and Nominator. *Omni Science* 7(1) 4-10.
 29. H. S. Virk (2018) Uranium Content Anomalies in Groundwaters of Ferozepur District of Punjab (India) and the corresponding risk factors. *Research & Reviews: Journal of Oncology and Hematology* 6(3), 18-24.
 30. Hardev Singh Virk (2018) My Journey from Cosmic Rays to Elementary Particles. *Research & Reviews: Journal of Space Science & Technology* 7(1), 35-38.
 31. Hardev Singh Virk (2018) My Journey in Earth Sciences and Creation of Physics Department in Guru Nanak Dev Univ., Amritsar. *Research & Reviews: Journal of Space Science & Technology* 7(1), 39-46.
 32. Hardev Singh Virk (2018) Flouride Contamination of Groundwaters of Two Punjab Districts and its Implications. *Omni Science* 8(2), 25-31.
 33. Hardev Singh Virk (2018) My Scientific Journey in Nanotechnology. *Nano Trends* 20(2), 48-54.
 34. Hardev Singh Virk (2018) Radon Studies for Uranium Exploration, Environment Health Hazards and Earthquake Prediction. *Research & Reviews: Journal of Space Science & Technology*. 7(2), 11-20.
 35. Hardev Singh Virk (2018) Heavy Ion Radiation Damage Track Studies in SSNTDs (Polymers, Glasses and Minerals) and Single Activation Energy Model. *Research & Reviews: Journal of Space Science & Technology*. 7(2), 1-10.

36. Hardev Singh Virk (2018) Selenium Contamination of Groundwater of Majha Belt of Punjab (India). *Research & Reviews: A Journal of Toxicology*. 8(2), 1–7.
37. Hardev Singh Virk (2018) My Forays into History and Philosophy of Science and Other Areas. *Omni Science* 8(3), 1-5.
38. Hardev Singh Virk. Shanghai Rankings 2018: Poor Performance of Indian Universities and IITs. *Omni Science* 8(3), 6-10.

Physics Education and other Publications

1. Virk H S (1969) Sources of Stellar Energy. *Vigyan de Naksh*, pp.83-88, P.U. Patiala.
2. Virk H S (1969) Cosmology : Religious and Scientific aspects. *Khoj Patrika*, pp.150-161, P.U. Patiala.
3. Virk H S (1970) Wonders of Atomic Energy (Punjabi). *Vigyan de Naksh*, pp.51-58, P. U. Patiala.
4. Virk H S (1973) Search for light Elementary Particles. *Vigyan de Naksh*, pp.49-53, P. U. Patiala.
5. Virk H S (1974) Dating of Rocks (Punjabi). *Vigyan de Naksh*, pp.93-96, Punjabi University, Patiala.
6. Virk H S (1974) Concept of Time (Punjabi). *Vigyan Darpan*, pp.19-28, Punjab State Univ. Text Book Board, Chandigarh.
7. Virk H S (1974) Cosmology in Science and Religion. *Proceedings Summer School History of Science*, INSA, New Delhi.
8. Virk H S (1976) Teaching of Science in Punjab Schools: A Survey (Punjabi). *Sikhya Patrika*, pp.59-61, Punjabi University, Patiala.
9. Virk H S (March 1976) Teaching of Science in Punjab Schools-A Critical Survey. *School Science*, pp.1-5, NCERT, New Delhi.
10. Virk H S (1979) Medium for teaching of Science and Technology (Punjabi). *Sikhya Patrika*, Punjabi University, Patiala.
11. Virk H S (1980) Punjabi Poetry : A study in Interactions (Punjabi). *Khoj Darpan (GNDU, Amritsar)*, 7, 57-63.
12. Virk H S (1981) Problems of teaching science in Punjabi medium (Punjabi). *Proc. of Punjabi Development Seminar held at Pbi. Univ., Patiala (Nov. 13-15)*.
13. Virk H S (1982) Cosmology in Science and Religion. *J. of Sikh Studies (GNDU, Amritsar)*, 9, 19-30.
14. Virk H S (1982) Role of scientists in the development of Punjab (Punjabi). *Proc. of 1st Punjabi Conference held at Pbi. Univ., Patiala (Nov. 2-4)*.
15. Virk H S (1983) Punjabi culture in the scientific age (Punjabi). *Proc. of*

- 2nd Punjabi Conference held at Pbi. Univ., Patiala (Dec.7-9).
16. Virk H S (1984) M. Phil Programme - An overview. IAPT Bulletin, 1, 18-19.
 17. Virk H S (1985) Post-graduate teaching of Physics -A model approach. IAPT Bulletin, 2, 107-108.
 18. Virk H S (1985) Improvement of under-graduate Physics education. IAPT Bulletin, 2, 177-178.
 19. Virk H S (1985) Gurmat Kav and Modern Science (Punjabi). Khoj Patrika, Punjabi University, Patiala.
 20. Singh A and Virk H S (1986) Creative teaching of Physics - A survey report. IAPT Bulletin, 3, 93-95.
 21. Virk H S and Singh A (1986) Teaching of Physics: Students Point of View-A Survey Report. IAPT Bulletin, 3, 315-317.
 22. Virk H S (1987) Our Experiment with M.Phil Programme. IAPT Bulletin, 4, 299-300.
 23. Virk H S (1987) Nature of Reality - physical and metaphysical interpretations. IAPT Bulletin, 4, 326-330.
 24. Virk H S (1987) Progress of SSNTD research in India. Science and Culture, 53, 12-15.
 25. Virk HS (1988) Current status of Science and Technology. IAPT Bulletin, 5, 91-92.
 26. Virk H S (1988) India marches ahead in SSNTD research. Science and Culture, 54, 325-326.
 27. Virk H S (1989) Forecasting of Earthquakes. IAPT Bulletin, 6, 265-270.
 28. Virk H S (1989) Conceptual problems of learning Physics. IAPT Bulletin, 6, 264.
 29. Virk H S (1991) The Gurus, the Sikhs and the Khalsa. The Tribune, Feb. 17.
 30. Virk HS (1992) Science and Society: Guest Editorial. IAPT Bulletin, 9, 68.
 31. Virk HS (1993) The fate of experimental physics in India. IAPT Bulletin, 10, 275-276.
 32. Virk H S (1993) My rendezvous in China. IAPT Bulletin, 10, 81.
 33. Virk HS (1994) Research in American University system. IAPT Bulletin, 11, 178.
 34. Garg A K, S Amrita Kaur and Virk H S (1994) Applications of conductivity cell in pollution control. Ind. Sci. Cruiser, 8, 11-13.
 35. Virk H S (1994) My reminiscence as a Physicist. Indian Physics Society, Diamond Jubilee Souvenir, IACS, Calcutta, pp. 51-52.
 36. S. Amrita Kaur and Virk H S (1995) Some applications of ion track

- membranes (filters): An overview. IAPT Bulletin, 12, 78-79.
37. Virk H S (1995) Report of Ninth Annual Convention of IAPT, held at G.N.D. University, Amritsar. IAPT Bulletin, 12, 147-149.
 38. Virk H S (1995) Sikh religion and modern science (Punjabi). Proc. of World Sikh Conference, SGPC, Amritsar, pp. 88-91.
 39. Virk H S (1996) Forecasting of Earthquakes: Danger signal for Punjab. Science Tribune, April 25.
 40. Virk H S (1996) Indian Science Congress : An Overview. IAPT Bulletin, 13(6), 165-166.
 41. Virk H S (1996) World-view in Sikhism , In Current Thoughts on Sikhism (Ed. Kharak Singh), Institute of Sikh Studies, Chandigarh, pp.251-259.
 42. Virk H S (1996) Study of Science in Punjab: A Historical Perspective. Ind. Sci. Cruiser, 10, 14-19.
 43. Virk HS (1997) A Genius Called Abdus Salam. IAPT Bulletin, 14, 114-117.
 44. Jain RK, RN Chakravarti and HS Virk (1997) An-400 keV Van de Graaff accelerator. IAPT Bulletin, 14, 284-285.
 45. Virk H S (1997) Professor D.P. Khandelwal: In Memorium. IAPT Bulletin, 14 (no.12) 402.
 46. Virk HS (1998) Decline in research in Indian Universities. Curr. Sci. 74 (no.5) 397.
 47. Virk HS (1998) Cost-effective databases for research. Curr. Sci., 75 (1), 5.
 48. Virk H S (1998) Who is the first Indian to work with Rutherford? Indian Sci. Cruiser, 12(1), 11.
 49. Virk H S (1998) Nuclear Explosions: Their detection and radioactive fallout. Science Tribune, June 4.
 50. Virk HS (1998) Indian Science: Ailments and remedies. Science Tribune, April 23.
 51. Virk HS (1998) What ails Indian Science? IAPT Bulletin, 15(no.4), 100.
 52. Virk H S (1998) Physics research in Indian and International context. IAPT Bulletin, 15(5),132.
 53. Virk HS (1998) Social and cultural interactions of science and technology. Ind. Sci. Cruiser, 12(3), 13-16.
 54. Virk H S (1998) What ails Indian science? Some suggested remedies. Curr. Sci., 74, 817-818.
 55. Virk H S (1998) Comments on paper of R.C. Ramola, "Assessment of health risk". Curr. Sci., 74 (8), 650-651.
 56. Virk H S (1999) Bureaucratisation of science in India. IAPT Bulletin, Guest Editorial, 16(2), 36.

57. Virk H S (1999) Ruchi Ram Sahni : who introduced scientific temper in Punjab. *The Tribune*, March 6.
58. Virk H S (1999) Sikhism: The Scientific Religion for the Mankind. *Understanding Sikhism-The Research Journal*, 1(1), 21-23.
59. Virk H S (1999) Discovering the roots of Punjabi culture in Uzbekistan. *The Sikh Review*.
60. Virk H S (2000) Frustrations of doing science in India. *Curr. Sci.*, 78(5), 101.
61. Virk H S (2000) Role of Indian science managers. *Curr.Sci.*, 78(6), 659.
62. Virk H S (2000) A peep into the History of Science development in India. *IAPT Bulletin*, 17(3), 72-73.
63. Virk H S (2000) Excitement in Physics: Myth & Reality. *IAPT Bulletin*, 17(8), 232-233.
64. Virk H S (2000) The fun of holding Indian Science Congress *melas*. *Curr. Sci.*, 78(9), 1052.
65. Virk H S (2000) Cocept of Sunya in Guru Granth Sahib (GGS). *The Sikh Review*, 48(6), 11-12.
66. Virk H S (2000) A bibliometric analysis of scientific research in India. *Curr. Sci.*, 78(11), 1280-1281.
67. Virk H S (2000) Decline in scientific research in Punjab. *University Today*,20(14),8.
68. Virk H S (2000) Wastage of resources & scientific manpower in India. *Curr. Sci.*, 79(7), 929.
69. Virk H S (2000) How to improve credibility of Indian Journals. *Curr. Sci.* 79(10), 1413.
70. Virk H S (2000) A case for History and Philosophy of Science in Indian universities. *Curr. Sci.*, 79(11), 1514.
71. Virk H S and Kaur S. Amrita(2000) Ion Track Filters: An Overview of Production and Application. *Ind. Sci. Cruiser*, 14(2), 22-24.
72. Virk H S (2000) Concept of Reality in Aad Guru Granth Sahib and its Physical, Metaphysical and Mystical aspect. *Understanding Sikhism-The Research Journal*, 2(1), 24-28.
73. Virk H S (2001) Siddha-Goshti: A projection of Sahaj-Yoga philosophy of Sikhism. *The Sikh Review*, 49 (8), 13-16.
74. Virk H S (2001) Beauty of Mathematical Equations in Physics. *Ind. Sci. Cruiser*, 15(1), 7-8.
75. Virk H S (2001) Vedic Astrology. *Curr. Sci.* 80(10), 1250-1251.
76. Virk H S (2001) Need for reforms in Indian National Science Academy. *Curr. Sci.* 80(11), 1364-1365.
77. Virk H S (2001) Report on International Conference on Natural Hazards : Mitigation & Management (ICNHMM) *Curr. Sci.*, 80(10), 1357-

- 1358.
78. Virk H S (2001) Importance of good teachers and leaders of research. *Curr. Sci.* 80 (12), 1477.
 79. Virk H S (2001) Improving research in India. *Curr. Sci.* 81(1), 10.
 80. Virk H S (2001) The emergence of third culture. *Curr. Sci.* 81(3), 232.
 81. Virk H S (2001) Appointment of Vice Chancellors in Universities. *Curr. Sci.* 81(6), 628-629..
 82. Virk H S (2001) Role of higher education in the Third World. *Curr. Sci.* 81(8), 868.
 83. Virk H S (2001) Importance of science policy and planning in India. *Curr. Sci.* 81(10), 1277.
 84. Virk H S (2001) The need for a National Institute of Seismology. *Curr. Sci.*, 81 (12), 1516.
 85. Virk H S (2001) Probable health hazards from nuclear weapon accidents in India and Pakistan. *Ind. Sci. Cruiser*, 15(4), 15-16.
 86. Virk H S, Kaur S.A. and Randhawa G.S. (2001) Role of ion track filters in environmental surveillance. *Ind. Jour. Environ. Protection*, 21(6), 529-533.
 87. Virk H S (2002) Physics research as a hobby. *Curr. Sci.*, 82 (1), 8.
 88. Virk H S (2002) The myth of Saraswati river. *Curr. Sci.*, 82(2), 117.
 89. Virk H S (2002) 12th National Solid State Nuclear Track Detectors: Conference Report. *Curr. Sci.*, 82(3), 254.
 90. Virk H S (2002) History of Science in Educational Institutions. *IAPT Bull.*, 19(2), 40-41.
 91. Virk H S (2002) The integrity of structures, individuals and institutions: The Sunder-Parida episode. *Curr. Sci.*, 82(5), 101.
 92. Marx G and Virk H S (2002) Life through the Nuclear Valley. *Ind. Sci. Cruiser* 16(1), 22-37.
 93. Virk H S (2002) Impact of impact factors and citation index analysis in research. *Ind. Sci. Cruiser*, 16(1), 13-14.
 94. Virk H S (2002) Sir Asutosh Mookerjee : A role model for Vice-Chancellors in India. *The Sunday Tribune*, 21 April, 2002.& *Ind. Sci. Cruiser* 16(3), 11-13.
 95. Virk H S and Walia Vivek (2002) Earthquakes: Causes, Precursors and Prediction. *Science India*, 5(6), 23-28.
 96. Virk H S (2002) How to promote scientific research as a career in India. *Curr. Sci.*, 82 (11), 1308.
 97. Virk H S (2002) Glaring disparities and digital divide in the Third World countries. *Ind. Sci. Cruiser* 16(2), 23-24.
 98. Virk H S (2002) Teaching of M.Sc. Physics courses: A survey report. *IAPT Bull.*, 19(10), 335-336.

99. Virk H S (2002) Priorities in science and technology. *Curr. Sci.*, 83 (7), 101.
100. Virk H S (2003) Improving the quality of Ph.D. students in Indian Universities. *Curr. Sci.* 84(4), 485.
101. Virk H S (2003) Competency-based training for informal sector as a National Policy. *Ind. Sci. Cruiser* 17(2), 50-51.
102. Virk H S (2003) Need for Value Education in present Global context. *Ind. Sci. Cruiser* 17(3), 55-56.
103. Virk H S (2003) Some suggestions to improve Indian Science Congress melas. *Curr. Sci.* 85(3), 240.
104. Virk H S (2004) Health of Indian Science. *Curr. Sci.* 86(10), 1349.
105. Virk H. S (2004) Fate of higher education in India. *Curr. Sci.* 86(12), 1585.
106. Virk H.S. (2004) Does India shine in scientific research? *Curr. Sci.* 87(1), 7.
107. Virk H.S. (2004) Shanghai rankings and Indian Universities. *Curr. Sci.* 87(4), 416.
108. Virk H.S. (2004) Reminiscences of G.N. Ramachandran. *Curr. Sci.* 87(11), 1496.
109. Virk H.S. (2004) Indian Science: Diagnosing malady and suggesting remedy. *Curr. Sci.* 87(12), 1642.
110. Virk H.S. (2004) Extra – terrestrial materials. *Ind. Sci. Cruiser* 18(4), 26-31.
111. Virk H.S. (2004) Cosmological Ideas in Science and Aad Guru Granth Sahib. *Omega Ind. J. Sci. & Religion*, 3(1) 72-75.
112. Virk H.S. (2005) Global perspectives in Science & Sikh religion. *Abstracts of Sikh Studies* 7(2) 15-20.
113. Virk H.S. (2014) Fundamentals of Picoscience. Book Review. *Curr. Sci.* 106(1), 101.
114. Virk H.S. (2014) Sarjit Singh Sandhu (1930–2014) Obituary. *Curr. Sci.* 107(2), 310.
115. Virk H.S. (2016) B.P. Chandra: Personal News. *Curr. Sci.* 111(4), 756-757.
116. Virk H.S. (2016) The need for developing Scientific Temper in India. *Curr. Sci.* 111(6), 961-962.
117. Virk H.S. (2016) Book Review: D.M. Bose - His Scientific Work in International Context. *Current Science* 111 (10), 1707-1708.
118. Virk H.S. (2016) India University Rankings 2016: poor performance of Indian Universities. *Current Science* 111(4), 601.
119. Virk H.S. (2016) Sikhs in Asia Pacific: Travels among the Sikh Diaspora

- from Yangon to Kobe. The Sikh Review 64(6), No. 750, 77-82.
120. Virk H. S. (2016) D. M. Bose – His Scientific Work in International Context. Curr. Sci. 111(10) 1707-08.
121. Virk H.S. (2016) Inside Story of the Nobel Peace Award - Indian Contestants. Sikh Review 64, 79-80.
122. Virk H.S. (2016) Bidhu Bhushan Ray – A Pioneer of X-Ray Spectroscopy. Curr. Sci. 113 (7), 1456-57.
123. Virk H.S. (2017) Need for a socially consistent Science & Technology Policy. Curr. Sci. 112(5), 893.
124. Virk H.S. (2017) How to reform our University system? Current Science 112(7), 1309.
125. Virk H.S. (2017) Fallacy of teaching - research nexus. Current Science 112(4), 673.
126. Virk H.S. (2017) Need for the introduction of undergraduate research in physics. Curr. Sci. 112(8), 1613.
127. Virk H.S. and Rajinder Singh (2017) The Sikh Scientist who was Nominator for the Nobel Prize. SikhNet Online, Dec. 13, 2016. <https://www.sikhnet.com/authors/hardev-singh-virk>
128. Virk H.S. (2018) A Review of Life of a Gurmukh: Sant Teja Singh. The Sikh Review 65, March 2018.
129. Virk H.S. (2018) New book explodes myth about cost of instruments used by C V Raman. India Science Wire, April 20, 2018.
130. Virk H.S. (2018) A botanical garden invisible to naked eyes. India Science Wire, May 7, 2018.
131. Virk H.S. (2018) Scientific Vision of Guru Nanak - The Universe and Stefan Hawking <https://www.sikhnet.com/authors/hardev-singh-virk>
132. Virk H.S. (2018) Reminiscences of My Visit to Espanola (1993). <https://www.sikhnet.com/authors/hardev-singh-virk>
133. Virk H.S. (2018) A Critical Evaluation of *Wahguru Gurmantar* in Sikh Religion. The Sikh Review, July 2018.

□

Appendix II

List of Books Published by Professor H.S. VIRK

A. Books in Punjabi

1. Virk H S (1970) *Brahmandi Kirna di Kahani* (Story of Cosmic Rays). Punjabi University, Patiala.
2. Virk H S (1978) *Brahmand Di Rachna* (Cosmology). Singh Brothers, Amritsar.
3. Virk H S (1988) *Adarsh ate Haqiqat* (Punjabi Translation of *Ideals and Realities* by Professor Abdus Salam, Nobel Laureate), Guru Nanak Dev University, Amritsar.
4. Virk H S (1990) *Sade Vigyani* (Our Scientists). Guru Nanak Dev University, Amritsar.
5. Virk H S (1994) *Vigyan de Krishme* (Wonders of Science). Guru Nanak Dev University, Amritsar.
6. Virk HS (2008) *Sikh Dharam ate Vigyan* (Sikh Religion & Science). Tarlochan Publishers, Chandigarh
7. Virk HS (2008) *Amrika- Canada Di Yatra* (Travels in America/ Canada). Tarlochan Publishers, Chandigarh
8. Virk HS (2008) *Meri Vishav Yatra* (My Travels around the Globe). Tarlochan Publishers, Chandigarh
9. Virk HS (2008) *Sikh Qaum da Dard ate Santap* (The Agony and Misfortune of the Sikh Nation). Tarlochan Publishers, Chandigarh
10. Virk HS (2009) *Europe da Safarnama* (Travelogue of Europe). Tarlochan Publishers, Chandigarh
11. Virk HS (2017) *Mera Jeevan Safar* (Journey of My Life). Gracious Books, opp. PU Patiala
12. Virk HS (2017) *Sikh Dharam Ate Vigyan* (Sikh Religion and Science (revised edition)). Panj Pani Parkashan, Mohali.
13. Virk HS (2017) *Ikivin Sadi Da Zafarnama*. Panj Pani Parkashan, D-12 Industrial Area, Phase I, Mohali.
14. Virk HS (2017) *Gurbani Di Saral Viakbia*. Panj Pani Parkashan, D-12 Industrial Area, Phase I, Mohali.

B. Books in English

15. Virk HS (2007) *Scientific Vision in Sri Guru Granth Sahib & Interfaith Dialogue*. Singh Bros. Amritsar.
16. Virk HS (2008) *Professor Puran Singh: Scientist, Poet & Philosopher*. Tarlochan Publishers, Chandigarh
17. Virk HS (Ed.) (2012) *Harmony in Science and Sikh Religion*. Singh Brothers, Amritsar (Distributors)
18. Virk HS (2018) *My Journey in Science: Autobiography of an Indian Scientist* (in Press)

C. Books in Science and Technology

19. Virk H S (1973) *Dhuni Vigyan* (Text Book on Sound). Punjabi University, Patiala.
20. Virk H S (1975) *Text Book of Physics for School Students* (Translation into Punjabi). PSEB, Mohali
21. Virk H S (1975) *Atom and its Nucleus* (Translation into Punjabi). Punjab State University Text Book Board, Chandigarh.
22. Virk H S (1977) *Tapgati Vigyan* (Text Book on Heat and Thermodynamics). Punjabi University, Patiala.
23. Virk H S (1978) *Atomi-Bhautic Vigyan* (Text Book on Atomic Physics). Punjabi University, Patiala.
24. Virk H S (1980) *Vayu Mandal* (Monograph on Atmosphere). Punjab State Languages Department, Patiala.
25. Virk H S (1983) *Nuclear Tracks: Methods and Applications* (Ed.). Guru Nanak Dev University, Amritsar.
26. Virk H S (1988) *History and Philosophy of Science* (Ed.). Guru Nanak Dev University, Amritsar.
27. Virk H S (1997) *Rare Gas Geochemistry: Applications in Earth and Environmental Sciences* (Ed.). Guru Nanak Dev University, Amritsar.
28. Virk HS (2004) *Vigyan ate Vigyani* (Science and Scientists). National Book Trust of India, New Delhi.
29. Virk HS and Kleemann W (Eds.) (2012) *Ferroics and Multiferroics*. Trans Tech, Switzerland.
30. Virk H.S. (Ed.) (2013) *Functional Nanomaterials and their Applications*. Trans Tech Switzerland.
31. RajshreeJotania and Virk H.S.(Eds.) (2013) *Ferrites and Ceramic Composites I*. Trans Tech Switzerland.
32. Virk H.S. (Ed.) (2013) *Radiation Damage Effects in Solids*. Trans Tech Switzerland.

33. Virk H.S. (Ed.) (2013) *Luminescence Related Phenomena and Applications*. Trans Tech Switzerland.
34. Virk H.S. (Ed.) (2014) *Luminescent Materials and their Applications*. Trans Tech Switzerland.
35. Virk H.S. (Ed.) (2014) *Luminescence: Basic Concepts, Applications and Instrumentation*. Trans Tech Switzerland.
36. Virk H.S. (Ed.) (2015) *Nanomaterials: Basic Concepts and Applications*. Trans Tech Switzerland.
37. Virk H.S. (Ed.) (2015) *Solid State Nuclear Track Detectors and their Applications*. Trans Tech Switzerland.
38. Virk H.S. (Ed.) (2015) *Radiation Damage Induced Modification of Materials*. Trans Tech Switzerland.
39. Virk H.S. (Ed.) (2015) *Ferroic Materials: Synthesis and Applications*. Trans Tech Switzerland.
40. Rajshree Jotania and Virk H.S. (Eds.) (2016) *Ferrites and Ceramic Composites II*. Trans Tech Switzerland.

□

Appendix III

A crisis situation due to Uranium and Heavy Metal contamination of ground waters in Punjab: A preliminary report

Uranium poisoning in Punjab first made news in March 2009, when a South African Clinical Metal Toxicologist, Carin Smit, visiting Faridkot city in Punjab found surprisingly high levels of uranium in 88% of the blood samples collected from amongst mentally retarded children in the Malwa belt of Punjab. The results revealed that 87% of children below 12 years and 82% beyond that age having uranium levels high enough to cause diseases, and in the case of one child, the levels were more than 60 times the maximum safe limit fixed by World Health Organisation (WHO). The reports of this study when published in local newspapers created a fear psychosis in the minds of the public. Many scientists from Universities of Punjab jumped on the bandwagon of Carin Smit to support her claim of high uranium content in blood samples by providing results of uranium analysis of soil and groundwater samples collected from some villages of Malwa belt of Punjab.

The echo of these reports resonated in the corridors of Indian Parliament and special efforts were made by a group of scientists of Bhabha Atomic Research Centre (BARC) and Guru Nanak Dev University, Amritsar (my old students and research collaborators) to delineate the causes of high U content in groundwater and soil of Malwa belt of Punjab. A public interest petition had been filed in Punjab and Haryana High Court at Chandigarh to monitor the progress made by the Scientists to find a solution to this problem. Recently, Centre

for Environmental Science and Technology, School of Environment and Earth Sciences, Central University of Punjab, Bathinda has entered this domain to study U and heavy metal content in soil and groundwater as well as in food chain. Tata Memorial Hospital has started functioning at Sangrur in Malwa belt to diagnose and monitor the cancer-causing agents and offer the treatment facility.

Punjab is facing a crisis situation due to high levels of Uranium (U) and heavy metals in the underground water table of Punjab. More than two dozen reports have been published in The Tribune (www.tribuneindia.com) during the last decade concerning high toxicity of U in the waters of Punjab. The latest report appeared on 18 May 2016, by Ruchika M. Khanna regarding the use of Canal water for drinking and toxic groundwater for purposes of irrigation. Ruchika report is based on the results of Uranium (U) reported by a team of scientists of BARC. It also refers to the presence of heavy metals in groundwater, pumped from the tubewells in rural areas of Punjab, based on the data collected by Punjab Water Supply and Sanitation Department (PWSSD). It will be of interest to the general public that PWSSD has collected data from more than 50% habitations (villages) of Punjab and analysed it in its sophisticated laboratory set up in Mohali (Punjab), using state of the art instrumentation including ICPMS (Inductively Coupled Plasma Mass Spectrometry). The analysis presented in this paper is also based on PWSSD data collected in 3 phases from 2009 to 2016 and compiled in April 2016. Most of this data is available on the Ministry of Water Resources, Government of India, website: www.indiawater.gov.in/IMIS reports.

Uranium in Groundwater: The total number of habitations (village or a cluster of houses) covered in PWSSD survey is 6182 in 3 phases. To demarcate quality affected (QA)

habitations, two limits have been set up by PWSSD in the data table: 30 microgram/litre (ppb) is called Acceptable Limit (AL) and 60 microgram/litre (ppb) is shown as Permissible Limit (PL) which has been set by BARC, Trombay (higher than limits set by all other countries). WHO limit is set at 15 microgram/litre (ppb). When we analyse the U data according to these limits, we get different results of QA habitations. According to PL criteria, 785 habitations are having QA groundwater in Punjab but when we use AL criteria, the number goes up to 1141. But I prefer to use WHO limit of 15 ppb for safe drinking water. Using this limit, the QA habitations augment to 2144, which is 35% of total habitations covered in PWSSD survey. As a matter of fact, more than one-third of Punjab groundwater is unfit for drinking purposes according to the international criteria set by WHO.

The highest number of QA habitations belong to Malwa belt, namely, districts of Fazilka (200), Moga (180), Barnala (120), Sangrur (95), Patiala (85), Bathinda and Mansa, followed by Tarn Taran, Hoshiarpur, Ludhiana and Jalandhar districts. SAS Nagar (Mohali) district has not a single habitation QA by high U; hence it has no source of U contamination in groundwater at all. A large variation of U content has been observed from district to district and habitation to habitation depending upon the nature and profile of groundwater which may depend upon geomorphology and geohydrology of the water table.

The highest U content in ground waters of Punjab has been recorded in 15 habitations of Hoshiarpur district in the range of 2109 to 2277 ppb, which is almost 20 times the average value of U content (115 ppb) for the whole of Punjab as per AL criteria. Both the average and the highest values of U content in ground waters of Punjab must set the alarm bells ringing for the general public as well as political leadership as

the health of Punjab population is at stake due to over-exploitation of groundwater for purposes of drinking and irrigation. Our calculation reveals that excess cancer risk for 2277 ppb U is 6.5 per 1000 persons, which is alarming! If we consider the average value of 115 ppb, the cancer risk for the whole of Punjab is 3.3 per 10,000 persons. There is an urgent need to study the epidemiological effects of high U content in drinking water on public health.

The health effects of U concentration in water on humans are not well documented. The overall indications are that there is no clear evidence of effects below an exposure concentration of 30 ppb. In fact, the evidence for effects on the kidney, which appears to be the most sensitive organ, is equivocal until much higher exposure concentrations. At higher concentrations, above about 100 ppb, radioactivity will begin to be a consideration.

Several methods are available for the removal of uranium from drinking-water, although some of these methods have been tested at laboratory or pilot scale only. Coagulation using ferric sulfate or aluminium sulfate at optimal pH and coagulant dosages can achieve 80–95% removal of uranium, whereas at least 99% removal can be achieved using lime softening, anion exchange resin or reverse osmosis (RO) processes. PWSSD has recommended the installation of RO system in rural areas of Punjab with U concentration higher than the Permissible Limit of 60 ppb. In our independent recent survey of some districts of Punjab, we observed that RO system has proved to be an effective and efficient technique in getting rid of U contamination from groundwater.

Heavy Metals

Iron content in Groundwater: The total number of habitations (village or a cluster of houses) covered in PWSSD survey is 4383 in 3 phases during 2009 to 2016. To demarcate

quality affected (QA) habitations, PWSSD has set an Acceptable Limit (AL) of 1 milligram/litre (ppm) for potable underground water to be used for public consumption. It has been reported by PWSSD that 539 habitations have a higher content of Iron in groundwater than AL value, as a consequence, the population inhabiting these will suffer from the overload effect of Iron. Normally, Iron deficiency in the human body leads to anemia and fatigue. But an overload of Iron in the body produces toxic effects leading to *hemochromatosis*, a severe disease that can damage body organs. The highest number of QA habitations are reported in Amritsar and Ropar, followed by Gurdaspur, Patiala and Tarn Taran districts. An overload of 14.58 ppm, the highest value in Punjab, has been detected in the water drawn from a hand pump of Bagrian village in Amritsar district. The other high values are reported from Harijan Abadi (8.90 ppm) of Tarn Taran; Harijan Basti, village Mangarh (8.99 ppm) of Fatehgarh Sahib; Bolri (8.83 ppm) in Patiala; and Daulowal (7.03 ppm) in Hoshiarpur district. To get rid of excess Iron from potable water, RO system is most effective.

Nickel and Cadmium content in Groundwater: Nickel and Cadmium AL values have been considered to be 0.02 ppm and 0.003 ppm, respectively. According to PWSSD report, 174 habitations are under QA category for Nickel and 165 for Cadmium out of a total number of 6404 habitations covered in this survey. Patiala district has the highest number of habitations with Cadmium overload. However, the highest value of Cadmium (0.22 ppm) is reported in groundwater of Marewal in Ludhiana district.

Mercury and Chromium content in Groundwater: The AL values for Mercury and Chromium have been taken as 0.001ppm and 0.05 ppm, respectively. Mercury has been detected in 107 habitations out of a total of 6831 covered in

this survey but the number of QA habitations is just 41. The highest value of Mercury (0.038 ppm) is reported in Hero Kalan village of Mansa district. Chromium content is widespread in Hoshiarpur, Ludhiana and Amritsar districts. However, the toxic effects of both these heavy metals need to be investigated epidemiologically for the safety of population in QA habitations.

Aluminium and Lead content in Groundwater: There are two limits set for Aluminium in groundwater of Punjab; Acceptable limit (AL=.03 mg/l or .03 ppm) and Permissible limit (PL = 0.2 mg/l or 0.2ppm). According to AL criteria, 3662 habitations out of a total of 6974 surveyed during 3 phases, show higher Aluminium content. If we consider the PL criteria, the number of QA habitations reduces to 1087. Aluminium contamination is highest in Hoshiarpur district with more than 150 habitations failing to qualify even under PL criteria. The highest value of Aluminum content (5.03 ppm) is reported for a tubewell installed in Balon village of SBS Nagar (Nawanshahar) district, which is 25 times the PL value.

Lead is another dangerous toxic heavy metal reported in Punjab. The AL for Lead has been set at 0.01 mg/l (0.01ppm). Out of 7009 habitations covered under Lead survey, 710 fail to qualify the safety limit. Gurdaspur district has the maximum number of failed habitations (128) followed by Jalandhar (98). The maximum reported value of Lead content (0.467 ppm) has been found in a cluster of villages in Jalandhar district, namely, Dhuleta, Patti Kamalpur and Bara Pind.

Arsenic and Selenium content in Groundwater: A team of Punjab Agriculture University (PAU) scientists reported their findings in The Tribune (Jan. 2, 2010) blaming Arsenic content in water of Malwa belt as the main cause of cancer. However, PWSSD survey report is more revealing and contradicts the

findings of PAU team. According to PWSSD report, with AL set at 0.01 mg/l (ppm), there are 2748 habitations out of 6884 surveyed in Punjab, which fall under QA category (40% nearly). Out of all QA habitations in Punjab, 60% fall in Majha belt of Punjab, namely, Amritsar and Tarn Taran districts. Gurdaspur occupies the 3rd position but the Malwa belt, including Patiala, Barnala, Mansa and Bathinda have fewer QA habitations due to excess or overload of Arsenic. SAS Nagar and SBS Nagar are relatively much safer with hardly any QA habitation. The source of Arsenic in groundwaters of Majha belt needs to be investigated. However, it is well established that the strongest evidence for a *cancer risk* involves arsenic, which is *linked to cancers* of the liver, lung, bladder, and kidney.

Selenium is a non-metal and a very useful component in our diet. Selenium is a nutritionally essential element. People need selenium for healthy joints, heart, and eyes. It plays a critical role in DNA synthesis, the immune system, and the reproductive system. It also helps fight cancer and other diseases. But its excess is dangerous for human health. Epidemiologic studies have shown that chronic exposure to selenium compounds is associated with several adverse health effects in humans.

Selenium AL is fixed at 0.01 mg/l (ppm) by the WHO. Following this criterion, PWSSD survey reported 587 QA habitations out of 7009 surveyed in Punjab. The maximum number of QA habitations fall under Jalandhar (130), Ludhiana (70), Patiala (55) and Tarn Taran (50) districts. However, the highest reported value of Selenium (2.00 ppm) has been reported in the tubewell water of Passiana village in Patiala district, which is 200 times the safe limit (AL).

Basic Parameters

TDS Contamination: This report undertakes the study of some basic parameters, namely, TDS (total dissolved salts),

Flouride, Chloride, Nitrate, Sulphate, Calcium and Magnesium. There are two limits defined by Punjab Water Supply and Sanitation Department (PWSSD) for analysis of quality affected (QA) groundwater inhabitations in Punjab. The Acceptable Limit (AL) for TDS is fixed at 500 mg/l (ppm) and Permissible Limit (PL) is allowed to be 2000 mg/l (ppm). Out of 2768 habitations surveyed in Punjab for TDS contamination, 609 are found to be QA according to AL criteria. However, using PL criteria, the number of QA habitations drops down drastically to 31 only. The highest value of TDS contamination (5650 ppm) has been found in 4 habitations of SBS Nagar district, namely, Jhungian, Mehatpur, Mehmoodpur Gadrian and Auladni.

Flouride and Chloride Contamination: The AL value for Flouride contamination in groundwater is fixed at 1.0 mg/l and PL value at 1.5 mg/l (ppm). Out of 3214 habitations surveyed in Punjab, 637 have been found to be QA using AL criteria. Flouride contamination is widespread in Patiala district of Punjab. However, the highest value of 11.39 ppm is recorded in village Jala Lakha Ke Hither in Fazilka district.

Chloride AL value is taken to be 250 mg/l (ppm) and PL value as 1000 mg/l (ppm). There are 41 QA habitations using AL criteria but none using PL criteria. The Chloride contamination is found to be highest in Fazilka district, accounting for almost 50% of total QA habitations.

Nitrate and Sulphate Contamination: The AL value of Nitrate allowed for Punjab is 45 mg/l (ppm). Out of 3197 habitations surveyed, 237 are found to be QA with the highest number falling in Patiala district. The highest value of Nitrate contamination (2553 ppm) is recorded in Sukhewal and Bhilowal villages of Patiala district.

The AL and PL values for Sulphate contamination are taken to be 200 ppm and 400 ppm, respectively. Using AL

criteria, there are 92 QA habitations in Punjab, with Fazilka district accounting for 40 out of 92. Pehar Kalan and Pehar Khurd of Patiala district record highest value of 4980 ppm of Sulphate contamination in Punjab.

Calcium and Magnesium Contamination: The AL values for Calcium and Magnesium are taken to be 75 ppm and 30 ppm, respectively. Out of 247 habitations surveyed in Punjab, 27 are QA with Amritsar accounting for 12. The maximum Calcium contamination of 297.6 ppm was found in Peher Kalan and Peher Khurd of Patiala district.

Magnesium AL value is fixed at 30 ppm. Out of 247 habitations surveyed, 125 are reported to be QA with the maximum number (54) falling in Fazilka district. Surprisingly, the highest contamination of Magnesium (145.75 ppm) is found in the same pair of villages, Peher Kalan and Peher Khurd, in Patiala district.

The data for Sodium and Potassium is not available. It will be interesting to investigate the contamination results of Peher Kalan and Peher Khurd in Patiala district for linkage between Calcium, Magnesium and Sulphate in groundwater.

Published by H.S. Virk in Research & Reviews: A Journal of Toxicology (2017), 7(2), 6–11p.